

SYLLABUS

TO

LECTURES ON CHEMISTRY.

BY

CHARLES UPHAM SHEPARD, M. D.

PROFESSOR OF CHEMISTRY IN THE MEDICAL COLLEGE OF THE STATE OF SOUTH
CAROLINA, AND LECTURER ON NATURAL HISTORY IN YALE COLLEGE.

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ADVERTISEMENT.

A FEW remarks only will be needed to explain the origin of these pages, and to indicate the sources of information whence they have been derived.

Having noticed the pains which some of my auditors have been at to transcribe the leading facts communicated in my lectures, both by taking notes at the time of their delivery, and subsequently by consulting the tables of composition, temperature, and physical qualities of bodies, with which my lecture-room has heretofore been furnished, and knowing that such a labor on their part could not be performed in the first case, except at the risk of often losing sight of the experiments, nor in the second, without interfering with other engagements during an exceedingly busy session, I have here made the attempt to supply my pupils with such an outline of my course, as shall effectually relieve them in future from these embarrassments. In drawing it up, I have been guided as to copiousness or brevity of statement, by the difficulty of the subjects discussed and the relative importance of the various substances described. Where the principles are clear and almost trite from having already entered into the great mass of popular information, they are simply announced in general terms, but on the other hand, where points of intricacy are involved which demand renewed attention in order to a clear conception of their value and bearing, fuller statements have been given: and when the topics have appeared to be unimportant, both in relation to theory and practical application, they have been alluded to in the briefest manner.

A much larger space has been given to organic chemistry in the Syllabus, than I am accustomed to devote to it in my lectures. This disproportion has been occasioned by a desire to bring forward the new and profound results in this department; and which are too recent in their origin to be found as yet in the text-books and systems of the science. It is in this point of view, that I venture to hope the Syllabus may be found worthy of the attention of chemical students at large; especially of those devoting themselves to the medical profession, and of such also as take an interest in the theory of agriculture.

The works from which I have drawn most copiously are the following: viz. An Introduction to Chemical Philosophy, by Prof. DANIEL, London, 1839; Chemistry of Organic Bodies, by Dr. THOMSON, London, 1838; Elements of Chemistry, by Prof. TURNER, as continued by Drs. W. G. TURNER, J. LIEBIG, and W. GREGORY, London, 1839 and 1841; and Organic Chemistry of Agriculture and Physiology, by Dr. J. LIEBIG, London, 1840. Wherever marks of quotation occur in the Syllabus prior to page 106, I am indebted to the first mentioned author; similar signs in the latter part of the work refer to the treatise of Dr. LIEBIG. It must be added also, that I have often employed passages from these and other chemical writers, where the change of language has rendered the introduction of such signs improper. Besides which, I have had frequent occasion to refer for facts, principles, and arrangement, to the works of BERZELIUS, FARADAY, URE, KANE, DUMAS, BERTHIER, MITSCHERLICH, SILLIMAN and HARE.

CHARLES UPHAM SHEPARD.

New Haven, Nov. 1, 1841.

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 CORRIGENDA.

- Page 115, 9 lines from the top, for cevaetic, read cevadic, or sabadillic.
 " " " " " for veradilla, " sabadilla.
 " 132, 2 " " for hypogae, " hypogæa.
 " 134, top line, for ottar, " attar.
 " 140, 10 lines from top, for Tulifera, " Toluifera.

SYLLABUS.

Experience the basis of natural knowledge.—The phenomena presented to the senses may be such as occur in the ordinary course of events, or they may result in some measure from human interference or contrivance. The former are called natural phenomena, the latter, experiments; both are included under experience.

Induction.—Hypothesis.—Theory.—Laws of Nature.—Deduction.—Phenomena or facts are to be compared one with another, and reasoned upon, in order to determine their relation as cause and effect. In searching after the governing principle among a number of similar facts, we frame a supposition, or *hypothesis*, which accounts for them more or less perfectly, without however embracing every condition they present. When at length the hypothesis is farther generalized, and exactly accommodated to the phenomena, it becomes a *theory*. The process of forming a theory is called *induction*, implying that the mind has been conducted from a detail of facts up to the governing principle or mode of action. This once established in the mind, it is enabled to anticipate during the action of the principle, what the facts will be; accordingly, the principle is said by a metaphor, to govern and determine the facts, and is termed a *law of nature*. *Deduction* is the converse process to induction, and consists in applying a law of nature not only to the resolution of those cases which were originally proposed to be determined, but also to such as had not been thought of, at the time the law was framed.

Force and Matter.—Resistance to touch in bodies by which we are surrounded, satisfies us of the existence of matter; while at the same time it renders us conscious of force. When we press the hand upon a table, we soon experience fatigue from the resistance to muscular effort. Here is force applied, and an obstacle encountered. If pressure against a mass of stone or

wood be adequate to overcome its resistance, its particles will be crushed, or the mass may be set in motion, according to the degree and nature of the pressure; but the result in either case illustrates the idea of force, as well as that of resistance. By the word matter in its most general sense, is associated resistance combined with extension.

Ultimate constitution of matter.—Concerning the properties of the primitive molecules or atoms, out of which bodies are formed, nothing is known with absolute certainty. They are too minute for our senses; and are theoretically believed to be indivisible, infinitely hard, and indestructible.

Forces of several kinds, and divisible into external and internal.—Animal force.—Mechanical force.—Weight.—Elasticity.—Attraction.—Repulsion.—Polar forces.—External forces act upon matter at sensible distances, internal (or molecular) forces act only upon molecules at insensible distances.

Attraction of gravitation (gravity). Every particle of matter in the universe attracts every other particle with a force, varying inversely as the square of the distance.

Weight is measured by the effort required to hinder a given mass of matter from obeying the law of gravity.—The balance.—Specific gravities; method for liquids; method for solids.—Elasticity, the resistance of a body under compression, or to extension. Elasticity of solids, of liquids, of gases. The air-pump.—Weight of air.—Barometer.—Atmospheric pressure.—Every body upon the surface of the earth at the level of the sea, supports an average pressure of fifteen pounds upon each square inch of its surface. The surface of a man of ordinary size sustains a pressure of fourteen tons.

Homogeneous attraction (cohesion).—It connects the particles of bodies together in the solid form, and exists in a feeble degree in liquids. It is measured by the amount of force required to separate the particles of bodies, or in other words, to break them. Strength of materials.—Friction between surfaces of similar matter.—Properties in bodies resulting from the force of cohesion: hardness, elasticity, brittleness, malleability, ductility, and compressibility.

Heterogeneous attraction (adhesion).—It causes the adhesion of particles of matter of totally different kinds.—Action of ce-

ments.—Friction between surfaces of dissimilar matter.—Capillary action.—Filtration.

Adhesion of gases to solids. Certain solids are capable of absorbing and retaining gaseous matter. Freshly burned charcoal takes up the following volumes or measures of the different gases, its own volume being taken at 1; ammonia 90; sulphurous acid 65; sulphuretted hydrogen 55; carbonic acid 35; oxygen 9.4, nitrogen 7.5. Aqueous vapor is imbibed by charcoal; also by certain animal and vegetable textures.—Hygrometer.

Adhesion of gaseous matter to liquids.—Aeration of water.—Mixture,—liquid with liquids.—Endosmose and exosmose, an arrangement of bodies in which the mutual attraction of two liquids is called into action, one of which is more capable than the other, of wetting a porous solid which forms part of the combination. Endosmose implies the flowing in of the exterior liquid; exosmose, the flowing out of the interior liquid.—Mixture of gases. All gases are capable of rapid diffusion through each other's masses. "One gas acts as a vacuum with respect to another."

Adhesion exists between different bodies with different degrees of force.—Elective attraction.

Mode of overcoming adhesion, or the separation of bodies united by heterogeneous attraction.—Evaporation.—Distillation.—Solids during their separation from liquids assume regular forms.

Crystallization.—Mode of obtaining regular crystals.—Forms of crystals.*—All the forms of crystals may be traced back to

* To prepare those who are unacquainted with geometry for a ready apprehension of the more obvious relations of crystals, the following elementary definitions are given.

The surfaces which limit a crystal are termed its planes or faces.

The lines produced by the meeting of the planes and faces are termed edges.

The meeting of any two edges forms a plane angle.

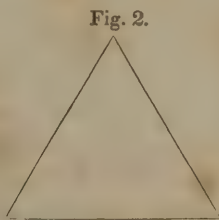
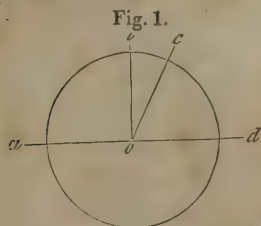
The measure, or as it is sometimes termed, the value of an angle, is the number of degrees, minutes and seconds of which it consists, these being determined by the portion of a circle which would be intercepted by the two lines forming the angle, supposing the point of their meeting to be in the centre of the circle. For the purpose of measuring angles, the circle is divided into three hundred and sixty equal parts, which are called degrees, each degree into sixty parts, which are called minutes, and each minute into sixty seconds; and these divisions are thus designated, $360^{\circ} 60' 60''$, the $^{\circ}$ signifying degrees, the $'$ minutes, and the $''$ seconds.

eight leading figures, called primary forms; viz. 1. the cube; 2. the right square prism; 3. the right rectangular prism; 4. the right rhombic prism; 5. the right oblique angled prism; 6. the

If one fourth of the circle, or 90° , be intercepted by the two lines ao , ob , Fig. 1, which meet at an angle aob in the centre, those lines are perpendicular to each other, and the angle at which they meet is said to measure 90° , and is termed a right angle. If less than one fourth of the circle be so intercepted, as by the lines bo , oc , the angle boc will measure less than 90° , and is said to be acute. If it measure more than 90° , as it would, if the angle were formed by the lines ao , oc , it is called obtuse.

The meeting of three or more plane angles forms a solid angle.

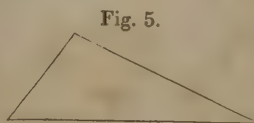
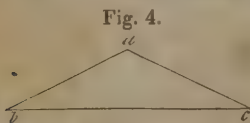
The faces of a regular form are said to be similar to one another, whose corresponding edges are proportional, and whose corresponding angles are equal. The similar faces of crystals, however, are not always equal to each other in size. Sometimes one or two faces are more extended than the rest. Crystallography in developing the relations of crystals, takes no notice of such accidental irregularities, but treats their forms as they are presented in their highest regularity and perfection.



Edges are said to be similar when formed by the meeting of faces equally inclined to each other. Similar edges are liable to the same irregularity as similar faces.

Plane angles are similar where they are equal, and contained within similar edges respectively. Solid angles are similar when formed of an equal number of plane angles, of which the corresponding ones are similar.

A triangle is a plane figure contained within three sides. When the sides are equal, it is called an equilateral triangle. Fig. 2.



The angles of an equilateral triangle are equal. A triangle having but two equal sides is called an isosceles triangle, Figs. 3 and 4. In Fig. 3, the two equal sides contain an angle less than 90° , and in Fig. 4 an angle greater than 90° . Fig. 3 is therefore called an acute triangle, and Fig. 4 an obtuse triangle. The unequal side bc is called the base of the triangle. The angles abc and acb , which are adjacent to the base, are equal to one another. A triangle with all its sides unequal is

oblique rhombic prism; 7. the doubly oblique prism; 8. the rhomboid.

The cube is contained under six square faces. All its angles are right angles.

The right square prism* is a quadrangular prism, whose bases are equal squares, and whose sides are equal rectangles. The vertical or lateral edges are always longer or shorter than the terminal ones. If these edges are equal, the form becomes a cube.

The right rectangular prism is a quadrangular prism whose bases are equal rectangles. The lateral edges cc , Fig. 9, are similar, but differ in length from the terminal ab , which are not equal.

Fig. 9.

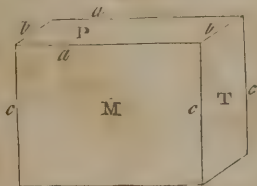
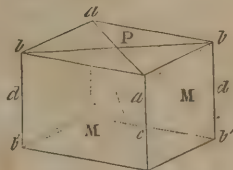


Fig. 10.



The right rhombic prism is a quadrangular prism, whose bases are equal rhombs, and whose lateral planes are either equal squares or equal rectangles. Fig. 10 is drawn with the greater

termed a scalene triangle, Fig. 5, in which all the angles also are unequal. A square has four equal sides, Fig. 6. A rectangle has its opposite sides only,

Fig. 6.

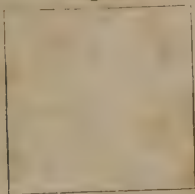


Fig. 7.

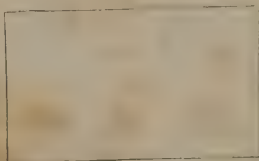


Fig. 8.



equal; its adjacent sides are unequal, Fig. 7. Like the square, its angles are all right angles. A rhomb has four equal sides, Fig. 8. Two of its angles, as a and c are obtuse; the other two, d and b are acute.

* Those prisms which stand perpendicularly when resting on one of their bases are called right prisms; those which incline from the perpendicular are called oblique prisms.

diagonal* bb of the bases, horizontal. The solid angles at a are the obtuse, and those at b the acute solid angles. The edge d and its opposite are the acute, and the edge c and its opposite the obtuse lateral edges. It has two greater and two lesser axes.† The greater axes pass through the solid angles which terminate the acute edges of the prism at bb , and the lesser through those which terminate the obtuse edges of the prism, at aa . Crystals having this primary form afford a great variety of particular prisms, differing in the inclination of M on M . Sulphate of magnesia, (epsom-salts,) for example, crystallizes in right rhombic prisms in which M inclines to M under $90^\circ 30'$, sulphate of zinc, (white vitriol,) under $90^\circ 42'$, sulphate of barytes, under $101^\circ 42'$, sulphate of lead under $103^\circ 42'$, and arsenical iron under $111^\circ 42'$.

The right oblique angled prism, Fig. 11, is a quadrangular prism, whose bases are equal oblique angled parallelograms. The adjacent lateral faces are unequal. T is a rectangle; but M may be either a square or rectangle. The angles and edges of this class of prisms are designated like those of the right rhombic prism, excepting the terminal edges, which are distinguished into the greater and the lesser terminal edges. The individuals of this class of primary forms will differ in the inclination of M on T . In sulphate of lime M on $T = 113^\circ 8'$, in phosphate of iron $= 125^\circ 15'$, and in arseniate of cobalt, $124^\circ 51'$.

Fig. 11.

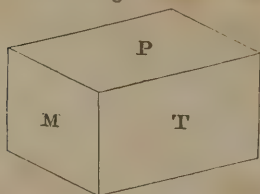
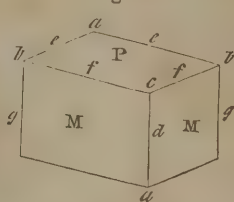


Fig. 12.



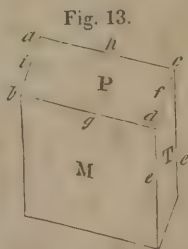
The oblique rhombic prism is a quadrangular prism whose bases are equal rhombs, and whose lateral faces are equal oblique-angled parallelograms. Fig. 12 is supposed to lean in

* A line connecting the opposite angles of any parallelogram is termed a diagonal of that figure.

† An axis is a line passing through the centre of a solid, drawn from any angular point, formed by the meeting of equal plane angles, to the opposite angle or face.

the direction ca , so that the terminal plane P forms an oblique angle with the edge d . The solid angle at a will in either case be called the acute solid angle, that at c the obtuse solid angle, and those at b the lateral solid angles. The edges e are called the acute terminal edges, and those at f the obtuse terminal edges. The edge d and its opposite are the oblique edges of the prism, and those at g and its opposite the lateral edges of the prism. The planes MM may meet at an acute or an obtuse angle; in the former case the prism is said to be oblique from an acute edge, and in the latter, oblique from an obtuse edge. The individuals referable to this primary form will differ from each other in the inclination of M on M . In sulphate of iron (copperas) the angle is $82^\circ 20'$, and in bi-borate of soda (borax) $133^\circ 30'$.

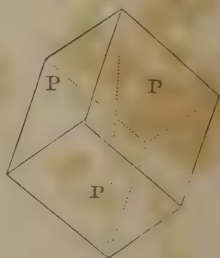
The doubly oblique prism is a quadrangular prism, whose bases are equal oblique angled parallelograms, and whose prismatic axis inclines from a perpendicular. The lateral faces of this solid are generally oblique angled parallelograms; two of them are always of this figure, the other two may be rhombs. The only equality subsisting among the faces is between each pair of opposite ones. The figure is supposed to be oblique in the direction da , so that the terminal plane forms an obtuse angle with the edge e . The solid angle at a is called the acute solid angle, that at d the obtuse solid angle, while those at b and c are called the lateral solid angles. The edges f and g are the obtuse terminal edges, those at h and i the acute terminal edges. The edge e and its opposite form the obtuse lateral edges, while k and its opposite are termed the acute lateral edges. The individuals belonging to this class will differ in three sets of angles, viz. P on M , P on T , and M on T . The following angles, for example, occur in sulphate of copper (blue vitriol,) P on $M = 127^\circ 30'$, P on $T = 115^\circ$, and M on $T = 93^\circ 30'$.



The rhomboid is contained under six equal rhombic planes. Its angular extremities are of two kinds; one of these consists of but two similar solid angles, and the line which connects them,

as ab , is the perpendicular axis of the solid : where this is vertical, the rhomboid is said to be in position. The two opposite solid angles a and b , situated at the extremities of the perpendicular axis, are called the solid angles of the summit, or the terminal solid angles ; the six remaining solid angles, are termed the lateral solid angles. The six edges which lead from the lateral to the terminal solid angles are denominated the edges of the summit, or the terminal edges, while the others are called the lower edges or the lateral edges of the rhomboid.

Fig. 14.



The individuals of this primary form differ by the inclination of P on P . When the angle measures more than 90° the rhomboid is said to be obtuse ; when less, acute. Sesquioxide of iron (specular iron) crystals are derived from a rhomboid of $86^\circ 10'$, carbonate of lime (calcite) from one of $105^\circ 5'$, and carbonate of iron from one of 107° .

Secondary forms. Any modification of either of the preceding forms is called a secondary form of such a primary. It arises from the replacement of some edge or angle of the present form, and the consequent substitution of one or more faces in its place. Whenever this alteration of the primary takes place upon one edge or angle of a solid, it extends to every similar edge or angle of the form, (except in those comparatively rare instances in which it is limited to one half the similar edges and angles.*) The following are a few illustrations of this law.

Fig. 15.

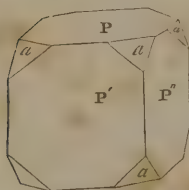


Fig. 16.

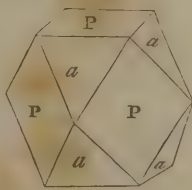
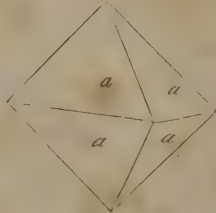


Fig. 17.



Secondary forms from the cube. (Fig. 15.) Modification a . Each angle replaced by a single plane. The new plane a is call-

* Such secondary forms are said to be hemihedral.

ed a secondary plane. Its inclination to each of the adjoining primary planes P P' P'' being the same, it is called a tangent plane.

Fig. 16 represents the same modification, but with the planes a more extended than in Fig. 15. The planes a are so far produced in Fig. 17 as to give rise to the regular octahedron, a form contained under eight equilateral triangles. Its plane angles = 60° . The inclination of the faces united by its edges = $109^\circ 28' 16''$, of those united by their angles = $70^\circ 31' 43''$. It is one of the most abundant forms among crystals.

In Figs. 18 and 19, may be seen another modification of the cube taking place through the tangent replacement of its edges. In Fig. 18, the secondary planes b are so far extended as to reduce the faces of the cube to about half their proper dimensions;

Fig. 18.

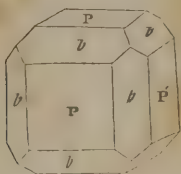
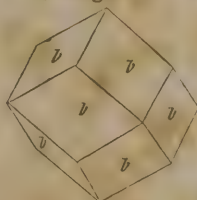


Fig. 19.



in Fig. 19, the faces b are produced to the complete extinction of the cubical planes, and the figure has become the rhombic dodecahedron, being contained under twelve equal rhombic faces, the mutual inclination of whose planes united by their edges, is 120° .

Figs. 20 and 21 elucidate a modification of the cube through the replacement of its edges by two planes c , inclining equally to the contiguous primary faces P . This kind of modification is

Fig. 20.

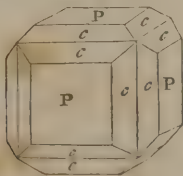
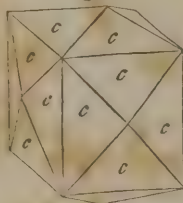


Fig. 21.



called a bevelment. The same faces are extended to the obliteration of the cubical planes in Fig. 21, when a new form bounded by twenty four isosceles triangles is produced, and which has been called the hexahedral trigonal-icositetrahedron.

Another frequent modification of the cube results from the replacement of its angles by three planes, inclining at an equal angle towards the primary planes, as in Fig. 22. When these new planes are supposed to be extended to the suppression of the cubical planes, the new form illustrated in Fig. 23 makes its appearance. It is called the trapezohedron, and is bounded by twenty four trapezoidal* faces.

Fig. 22.

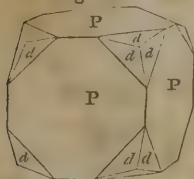
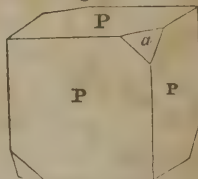


Fig. 23.



Fig. 24.



Hemihedral forms derived from the cube. The alternate angles are replaced by tangent planes in Fig. 24, and the new faces *a* are extended in Fig. 25 to the extinction of the primary planes. This secondary form is bounded by four equilateral triangles, and is called the regular tetrahedron. The mutual inclination of its faces = $70^{\circ} 31' 43''$.

Fig. 25.

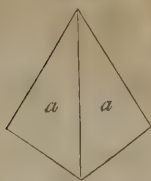


Fig. 26.

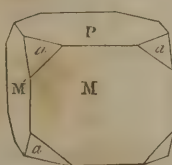
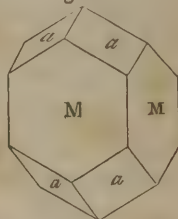


Fig. 27.



Figs. 26 and 27 exhibit secondary forms from the right square prism, in which the terminal angles are replaced by the single planes *a*; and Figs. 28 and 29 are alterations of the same primary,

Fig. 28.

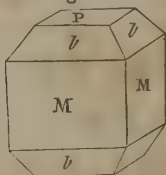
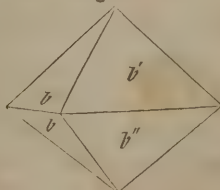


Fig. 29.



* A trapezium has four unequal sides, no two of which are parallel.

through the replacement of the terminal edges by the single planes *b*.

The lateral edges only have been affected by a similar replacement in Fig. 30; while in Fig. 31 is observed a combination of all the preceding modifications of the right square prism.

Fig. 30.

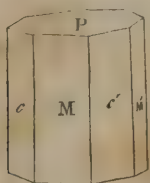
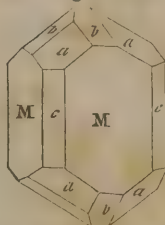


Fig. 31.



Omitting the notice of modifications upon the other primary forms as being of a nature easily intelligible, the following figures are given to exhibit the derivation of the regular hexagonal prism as a secondary from the rhomboid.

Fig. 32.

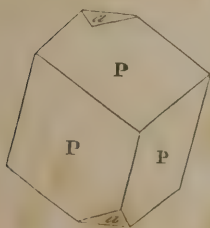


Fig. 33.

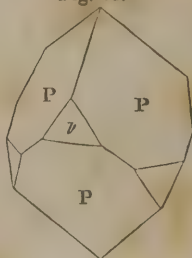


Fig. 34.

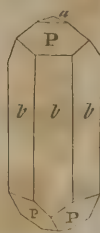


Fig. 35.

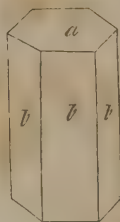


Fig. 32, the rhomboid with its summit replaced by single planes.

Fig. 33, the rhomboid with its lateral angles replaced by single planes.

Fig. 34, a combination of the two foregoing modifications, in which the planes *b* are broadly extended.

Fig. 35, differs from the last in the extension of the planes *a* so far as to extinguish the remains of the primary faces *P*.

Intersected or twin crystals.—

Internal structure of crystals. The internal structure of crystals depends upon the connexion existing among their particles. It may be observed by mechanically overcoming this connexion. In effecting such a separation, smooth and polished surfaces are of-

ten produced in certain directions, and where a smooth surface is thus produced in any direction, others may also be effected in the same direction. Two or more of these being developed in a crystal give origin to plates or laminæ, from whence the expression, foliated structure or laminated structure, which has been applied to such crystals. If an attempt be made to cleave a crystal in a direction contrary to its natural joints, much more force will be required to overcome the connexion of the parts, and an uneven surface will be the result. The production of even and polished surfaces, in causing the separation of the particles of crystals, is denominated their cleavage; of uneven and irregular surfaces, their fractures. The faces which result from cleaving a crystal may be termed its cleavage planes. These often differ in respect to lustre. Those which are parallel in the same crystal, however, are always similar in this respect, while those which are not parallel often present considerable diversity. A regular solid contained within cleavage planes is called a form of cleavage, or a cleavage-crystal.

Relation between forms of cleavage and primary forms.

Dimorphism.

Methods for determining the angles of crystals.—Goniometers.

Interrupted or imperfect crystallization.—Substances not occurring under a determinate number of planes, meeting under fixed angles, are said to be massive. They are often highly crystalline in their structure, and may sometimes very readily yield cleavage-forms, while in other instances they merely separate on the application of force into distinct concretions, such as fibres and grains. These concretions must be regarded as imperfectly formed crystals, which have been hindered from becoming regular, owing to the unfavorable circumstances under which they were produced.

Repulsion (the antagonist of cohesion) produced by

Heat.—The particles of the firmest metal have their attraction weakened when subjected to a sufficient heat; and provided the heat be intense enough, the metal rises in the form of vapor, a state in which mutual repulsion is generated among the particles.

Active sources of heat.—The sun, friction, chemical, electricity, physiological, internal heat of the earth.

Expansion from heat.—It differs in different classes of substances, as well as among bodies of the same class. Among solids. In heating 350 cubic inches of lead from the freezing to the boiling point of water, they become 351, 800 of iron become 801, and 1000 of glass 1001. Among liquids. By the same change of temperature

1000 cubic inches of water become	-	1046
1000 " oil,	- - -	1080
1000 " mercury,	- - -	1018
1000 " alcohol,	- - -	1110

Among gases. Every aeriform body, provided it be not in contact with a liquid, expands in the same proportion. 1000 cubic inches of atmospheric air become 1373 by being heated from the freezing to the boiling point of water.

Measurers of heat. The principle of the thermometer. A certain quantity of air, or of a liquid, or solid, is observed to expand to the same dimensions when subjected to the same degree of heat, however often the experiment be repeated; and if exposed to another heat, which causes double the expansion, we infer that the intensity of heat in the second case is double that in the first. Thermometer of SANCTORIO, Differential thermometer, Mercurial thermometer, Alcoholic thermometer, Pyrometers.

Applications of the force of expansion.

Exception to the law of expansion in water. Water in cooling from 40° to 32° expands.

Conduction of heat, is the process by which heat travels through a solid body. The property varies much in different bodies: metals are the best conductors, though they vary among themselves, as may be seen in the following table:

Gold,	-	1000	Iron,	-	374.3
Silver,	-	973	Zinc,	-	363.
Copper,	-	898.2	Tin,	-	303.9
Platinum,	-	381	Lead,	-	179.6

Conduction of heat in liquids scarcely appreciable; does not exist at all, in aeriform bodies.

Applications of conduction.

Convection of heat, implies the diffusion of heat through a liquid or aeriform body, by means of the circulation or rapid

change in the relative positions of adjacent particles, which takes place during the process of heating. Convection in liquids.—Convection in gases.

Applications of convection. Ventilation. Trade winds. Gulf stream.

Heat of composition, (specific heat,) by which is understood the property whereby heat enters into the composition of bodies, attended with a loss of its character of temperature, it becoming latent to our senses, as well as instruments. Equal volumes of the same liquid at different temperatures, afford upon mixture the mean temperature of the two. Thus, a pint of water at 50° , being mixed with a pint at 100° , the resulting temperature will be 75° . If however, a pint of quicksilver at 100° be agitated with a pint of water at 40° , the resulting temperature of the two will not be 70° or the mean, but 10° lower, or 60° ; so that the quicksilver will lose 40° , whereas the water will only gain 20° ; yet the water must contain the whole heat which the quicksilver has lost. Hence it appears that water has a greater capacity for heat than quicksilver; it requiring a larger quantity of heat to raise it to a given temperature. The truth of this inference is farther apparent from the converse of the experiment; for if a pint of water at 100° be mingled with a pint of quicksilver at 40° , the resulting temperature will be 80° : the water will fall 20° in temperature, but in so doing will give up heat sufficient to raise the quicksilver 40° . The same comparison may be made by weight. Thus if a pound of quicksilver at 40° be agitated with a pound of water at 156° , the resulting temperature will be $152^{\circ}.3$: the water will lose $3^{\circ}.7$ of temperature, but enough heat will be evolved to raise the metal $112^{\circ}.3$. Now the proportion of $3^{\circ}.7$ to $112^{\circ}.3$, is the same as 0.033 to 1 .; hence adopting water as the standard of comparison, we call the specific heat of quicksilver 0.033 , designating by the term specific heat, the heat peculiar to the species of matter compared with the standard.

Again: if a pound of water at 100° , and the same weight of oil at 50° , be mixed together, the resulting temperature will not be the mean, 75° , but $83^{\circ}.5$; the water therefore will lose $16\frac{3}{4}$, while the oil will gain $33\frac{1}{4}$; or reversing the temperatures, if the pound of water be 50° and the pound of oil 100° , the mean will

be $66\frac{1}{3}$, so that the oil will give out $33\frac{1}{3}$, and the water will rise only $16\frac{2}{3}$. Hence the heat which will raise the temperature of oil 2° , will raise an equal weight of water only 1° ; and the specific heat of oil will therefore be 0.5.

Effect of this different capacity of different bodies for heat upon their rates of heating and cooling.

Method of ascertaining specific heats, invented by MM. LAVOSIER and LA PLACE.

Table of specific heats, the specific heat of water being reckoned as 1° .

Hydrogen gas,	3.2936	Oxygen, -	0.2361
Water, - -	1.0000	Carbonic acid,	0.2210
Aqueous vapor,	0.8470	Charcoal, -	0.2631
Alcohol, -	0.7000	Sulphur, -	0.1850
Ether, - -	0.6600	Iron, -	0.1100
Oil, - - -	0.5200	Mercury, -	0.0330
Nitrogen gas, -	0.2754	Platinum, -	0.0314
Atmospheric air,	0.2669	Gold, -	0.0298

The specific heat of bodies increases as their temperature rises, it requiring more heat to raise them a certain number of degrees, when at a high than when at a low temperature.

Specific heat of iron from 32° to 212°	-	0.1098
“ “ 392	-	0.1150
“ “ 572	-	0.1218
“ “ 662	-	0.1255
Mercury 32 to 212	-	0.0330
“ “ 572	-	0.0350
Glass 32 to 212	-	0.1770
“ “ 572	-	0.1900

The condensation of the particles of bodies attended by elevation of temperature, and their dilatation with the opposite effect;—phenomena which are probably owing to changes produced in the specific heat of such bodies.

Influence of the increased capacity of air for heat during its rarefaction upon the temperature of the atmosphere. The temperature of the air falls 1° for every 300 feet of ascent.

Latent heat. Equal weight of water at 32° and of water at 212° , will produce on mixture, the mean temperature of 122° ; but equal weights of ice at 32° and of water at 212° only produce, after the ice has melted, a temperature of 52° : the water loses 160° of temperature, while the ice gains only 20; 140° of heat are therefore expended in changing the state of the ice from solid to liquid. This portion of heat becomes latent in the physical change which the ice has suffered in passing to the condition of water, or in being converted from a solid into a liquid. The fluid state is ascribable to these 140° of latent heat. That this heat is actually present in the water, and is in no way destroyed or annihilated, will appear from considering that water exposed to a degree of cold far below the freezing point, will gradually part with its excess of temperature above that of the surrounding bodies, and become colder and colder till it reaches the freezing point; but will not descend below 32° , till the whole has become ice, and yet it must continue yielding up heat at the same rate as before. There must therefore be within it a continued supply of heat, to keep it up to this fixed point: the moment the whole becomes too concrete, the temperature will begin to sink, and will soon reach that of the surrounding objects and medium.

Phenomena of liquefaction.—4 oz. of nitrate of ammonia with 4 oz. of carbonate of soda, dissolved in 4 oz. of water at 60° , will in three hours freeze 10 oz. of water in a metallic vessel immersed in the mixture, when the solution is in progress. A mixture of equal parts of snow or pounded ice and common salt will sink the thermometer from 32° to 0° .

All liquids remain fixed at the temperature of their congealing points during the process of liquefaction.

Table of congealing or fusing points.

Sulphuric ether, -	- 46°	Acetic acid, -	-	+ 50°
Mercury, -	- 39	Tallow, -	-	92
Oil of turpentine, -	+ 14	Wax, -	-	149
Water, -	- 32	Sulphur, -	-	218
Olive oil, -	- 36	Potassium, -	-	136

Sodium, - -	194°	Zinc, - -	773°
Alloy of bismuth, lead	} 212	Silver, - -	1873
and tin, - -		Copper, - -	1996
Tin, - -	442	Gold, - -	2016
Bismuth, - -	476	Cast iron, - -	2786
Lead, - -	612	Iron & platinum above	3280

Table of latent heat of liquids.

Water, - -	140°	Bees' wax, - -	175°
Sulphur, - -	143.7	Zinc, - -	494
Spermaceti, - -	145.	Tin, - -	500
Lead, - -	162.	Bismuth, - -	550

Vaporization and condensation.—Heat becomes latent again during the conversion of a liquid into a vapor, and is rendered sensible on its return to the liquid condition.

Every liquid, when of uniform purity and under the same atmospheric pressure, has one specific point at which it enters into ebullition: thus, pure water boils at 212°, alcohol (of a sp. gr.=0.813) at 173°, and ether at 96°.

Liquids under a diminished temperature, boil at lower temperatures. Under the receiver of an air-pump, water may be made to boil at the temperature of 32°; but the full amount of latent heat must be absorbed in its passage into the aeriform state. Boiling in *vacuo*. Freezing in *vacuo*.

Steam of high pressure.

Table of force and temperature of steam.

Atmospheres.	Temperatures.	Atmospheres.	Temperatures.
1	212°·00	10	358°·88
2	250 ·52	11	366 ·85
3	275 ·18	12	374 ·00
4	293 ·72	13	380 ·66
5	307 ·50	14	386 ·94
6	320 ·36	15	392 ·86
7	331 ·70	20	418 ·46
8	341 ·78	25	439 ·34
9	350 ·78	50	510 ·60

Quantity of heat which becomes latent in steam.—A quarter of a pint of water, raised to steam in a close boiler, on being deliv-

ered by a bent tube into ten quarter pints of cold water in a condensing vessel, will during condensation, raise the temperature of the cold water 90° . This experiment would fix the latent heat of steam at 900° , but nice investigations have determined it to be 1000° .

Table of latent heat of other vapors.

Vapor of alcohol,	-	-	-	-	457 $^{\circ}$ ·0
" ether,	-	-	-	-	312 ·9
" oil of turpentine,	-	-	-	-	183 ·8
" nitric acid,	-	-	-	-	550 ·0
" ammonia,	-	-	-	-	865 ·9
" vinegar,	-	-	-	-	903 ·0

The same weight of steam, whatever its density, contains the same quantity of heat; its latent heat being increased in proportion as its sensible heat is diminished or absorbed.

Table of the increase of volume from vaporization.

One cubic foot of water	gives	1689·00	cubic feet of vapor.
" " alcohol	"	493·50	" "
" " ether	"	212·18	" "
" " oil turpentine	"	192·15	" "

Steam of great elasticity when escaping from a boiler does not scald to a degree equal to steam of ordinary density.

The application of steam for power depends upon the elastic force of steam communicated by heat and the instantaneous annihilation of that force by cold.

Vapor formed from liquids at all temperatures.—Evaporation.

Table of the force and weight of steam at different temperatures.

Temperatures.	Inches of mercury.				Weight of cubic foot.
32 $^{\circ}$	-	-	0·216	-	2·530 grs.
40	-	-	0·280	-	3·230
50	-	-	0·400	-	4·530
60	-	-	0·560	-	6·220
70	-	-	0·770	-	8·390
80	-	-	1·060	-	11·330
90	-	-	1·430	-	15·000
212	-	-	30·000	-	257·218

The rate of evaporation increases with the surface and the temperature.—Hygrometers.

Difference between vapors and gases.

Liquefaction of gases.

Table of pressure in atmospheres.

			Atmosphere.			Temperature.
Sulphurous acid,	-	-	2	-	-	45°
Chlorine,	-	-	4	-	-	60
Cyanogen,	-	-	4	-	-	60
Ammonia,	-	-	6½	-	-	50
Sulphuretted hydrogen,	-	-	17	-	-	50
Carbonic acid,	-	-	36	-	-	32
Hydrochloric acid,	-	-	40	-	-	50
Nitrous oxide gas,	-	-	50	-	-	45

Before attending to the laws which regulate heat in motion through space, it will be proper to notice a subtle agent with which it is often associated, and with which it is connected by strong analogies.

Light.—Its sources. By the hypothesis of emission, light consists of a highly attenuated fluid, not possessed of gravity, but endued with a self-repulsive force, and projected from luminous substances in right lines, with inconceivable velocity. In the hypothesis of *undulation*, the whole universe is supposed to be filled with a highly elastic, rare medium, which possesses the property of inertia, but not gravitation, to which the name of ether has been given. Light is produced in this medium by an undulation analogous to the waves of water, or those vibrations of air which cause the impression of sound upon the ear. According to the first hypothesis, a ray of light consists of a line of particles projected from the luminous body and impinging upon the eye; according to the second, of a series of undulations excited by the luminous body, which reach the eye and produce the sensation of light by corresponding vibrations of the optic nerve.

Velocity of light, 195,000 miles in a second. Passage of light in straight lines, traversing some bodies (which are called transparent) and interrupted by others (which are called opaque).—The shadow. Effects of obstacles on the passage of light: one

portion is turned aside or reflected, another penetrating the medium is refracted, or bent out of its original direction, a third is absorbed or lost, and a fourth is repelled from the surface in all directions, suffering what is called secondary radiation.

Refractive power of substances is in some measure proportioned to their densities.

Table of the refractive power of various substances.

Air, - - -	1.000	Spirits of turpentine,	1.475
Oxygen, - - -	0.861	Alcohol, - -	1.372
Nitrogen, - - -	1.034	Ether, - - -	1.358
Hydrogen, - - -	6.614	Water, - - -	1.335
Ammonia, - - -	2.168	Diamond, - -	2.439
Carbonic acid, -	1.004	Phosphorus, -	2.224
Carburetted hydrogen,	2.092	Quartz, - - -	1.548
Vapor of ether, -	5.280	Ice, - - - -	1.308

Lenses and prisms.—Decomposition of light.—Solar spectrum.—Double refraction.—Polarization of light.

Radiant heat is subject to reflection, absorption, secondary radiation, refraction, and polarization.

Effect of surface on radiation and absorption. The best absorbents of heat are the best radiators.

Table of radiating powers.

Lampblack, - - - -	100
Writing paper, - - -	98
Crown glass, - - - -	90
China ink, - - - -	88
Red lead, - - - -	80
Plumbago, - - - -	75
Tarnished lead, - - -	45
Clean lead, - - - -	19
Polished iron, - - - -	15
Tin, } polished, - - - -	12
Gold, }	
Silver, }	
Copper, }	

Illustration of radiation and reflection in common experience.
Theory of the formation of dew.

Diathermancy of heat.—The power in bodies of transmitting rays of heat is not proportioned to their transparency. Some bodies which are highly transparent intercept nearly the whole of the calorific rays, while others allow the whole to pass through them. Different kinds of glass vary in this respect from 67 per cent. in flint glass, to 49 in crown glass; while perfectly transparent rock salt will transmit 92 out of every 100 rays, and equally transparent alum but 12. Bodies which transmit heat with facility are called diathermanous, those which do not allow of such transmission are athermanous.

Electricity.—Sources of electricity.

Electrical attraction and repulsion. A feather suspended by a silk thread and approached by a dry glass tube which has been rubbed with silk, will approach the glass tube from a distance and adhere to it for a moment, but will afterwards recede from it; and after its separation, the tube, in place of exerting any attraction upon it, will strongly repel it from its surface. By substituting a stick of sealing wax for the glass tube and rubbing it with a dry warm flannel, the same phenomena of attraction and repulsion will be produced upon a fresh feather. But if the excited wax be now presented to the feather which has received the repulsive property from the glass, or the excited glass to the light substance which is in a state to be repelled by the wax, strong attraction will be manifested in both cases. And not only does the originally excited glass or wax attract or repel those light portions of matter, but they communicate by contact the same properties to them; so that two feathers after having been attracted, will not only be repelled by the wax or glass respectively, but will repel each other, and their component fibres will become self-repulsive; but two feathers which have received the property from the different substances, though self-repulsive, will strongly attract each other. Theory of M. Du Fay with regard to these two states of activity,—two highly elastic imponderable fluids in matter, whose particles (of the fluids) are self-repulsive but attractive of each other; that evolved from glass was called vitreous electricity, that from resinous bodies was called resinous electricity. Modification of the hypothesis by Mr. SYMMER,—who showed that when two bodies are rubbed together both become

excited, and that one of them always possesses the vitreous and the other the resinous electricity. The two fluids always exist in all unexcited bodies in a state of combination and neutralization, when no electrical phenomena are apparent. Friction occasions the separation of the two fluids, and the electrical action continues till an equal quantity of that kind of electricity which has thus been withdrawn from the other has been restored and reunited with it. **Theory of Dr. FRANKLIN.** He supposed a single fluid to pervade every species of matter, which fluid is self-repulsive, but attracts the particles of matter, which the hypothesis further requires should be considered as self-repulsive when deprived of their natural portions of the electrical fluid. When, on this view, a glass tube is rubbed with a silk handkerchief, the electrical equilibrium of the fluid in the two substances is disturbed: the glass acquires more than the natural quantity, and is overcharged: the silk retains less than its natural quantity, and is undercharged. Thus electrical repulsion takes place between two bodies both of which contain more or less than their natural quantity of fluid, and electrical attraction is only excited between two bodies, one of which contains more or less than the other. One of these states is called positive and the other negative.

It is a necessary consequence of either view, that one species of electricity cannot be exerted without the evolution of the other. When the glass tube is rubbed by the silk, it is not only the glass, but the silk also which attracts light bodies.

Mode by which excited bodies return to their natural state.—After either electrical state has been conferred upon a body, it will slowly return to its natural state in a dry atmosphere, unless it be touched with some other body; but the nature of the substance by which it is touched influences materially the result. The naked hand will speedily remove the electricity: a metallic body will do it still more readily; but dry glass, resins, silk or sulphur will not prove effective. Hence the division of bodies into two classes, of conductors and non-conductors. In the following table, the left hand column commences with the most perfect conductors and ends with the least perfect conductors: the right

hand column commences with the least perfect conductors, and ends with the most perfect.

Conductors.	Non-conductors.
Metals,	Spermaceti,
Charcoal and plumbago,	Glass,
Fused chlorides,	Sulphur,
“ iodides,	Fixed oils,
“ salts,	Spirits of turpentine,
Strong acids,	Resins,
Alkaline solutions,	Ice,
Water,	Diamond,
Alcohol,	Shell-lac,
Damp air,	Oxalate of lime,
Vegetable and animal bodies.	Dry gases.

Insulation of electricity. Electrics and non-electrics. It was formerly supposed that the two great classes of conductors and non-conductors might be designated as non-electrics and electrics; the former name implying a capacity of electric excitement, and the latter a total incapacity of electric excitement, a distinction now found to be inaccurate.

Mode of determining the existence and nature of any electrical excitement. Electrometers.

The same substance not always similarly electrified by friction.

Electrical machines.

Method of distribution of electricity on excited surfaces.

Induction of electricity, or that influence which an electrified body exerts upon other bodies at such distances from it, as to prevent the direct transfer of any portion of the charge. The neutral state of an insulated conductor in its immediate vicinity will be destroyed: the end of the conductor which is nearest to the charged body is in an opposite state to that body, and the most remote end in the same state. The conductor has had a polar* state communicated to it. This distant action of an electrified body, by which its own charge is in no degree lessened, is distinguished by the name of induction. The secondary state

* Forces which are conceived to act with equal intensity in opposite directions at the extremities of the axes of molecules, or masses of matter, are denominated polar forces.

of the neighboring body is called induced electricity: and the body itself is said to be under induction. The originally active body is sometimes distinguished as the inductric or inductive body, and that under its influence as the inducteous body.

The mechanism of electrical phenomena. The phenomena of induced electricity were supposed to arise from an action of a charged body upon others at a distance in straight lines, through non-conducting media: the particles of which were assumed to be unaffected by it. Dr. FARADAY has shown induction to be an action of contiguous particles throughout, capable of propagation in curved lines and to be concerned in all electrical phenomena.

The thickness of insulating media has an important influence on the degree of induction. Electrical condenser. Electrical attraction owing to the previous developement of the opposite condition by induction. A pith ball or other light substance, placed upon a conducting surface under an electrified plate, is rendered inducteous and drawn upwards; but when it comes in contact with the plate, its inducteous state is destroyed; it is charged with similar electricity, and becoming inductric, it is attracted downwards and parts with its charge. Induction always precedes charge in insulated conductors, and the prime conductor of the machine has the resinous state strongly developed upon its points, previously to its becoming charged with the vitreous electricity of the excited glass.

Electrophorus.

The inductive properties of solid insulating media. *Dielectrics.*

By substituting a solid dielectric the state of tension is capable of rising to a degree, limited only by its cohesive force. If a plate of glass be coated on both sides with tinfoil within an inch or two of its edges all round, and one side be placed in connexion with the prime conductor of the electrical machine, we shall have an arrangement similar to that of the two plates of the condenser with its interposed stratum of air. Upon connecting the opposite coating with the ground to destroy its polar state, the particles of the glass are forced into a polarized or constrained position by the electricity of the charging apparatus; which is sustained till the return of these particles to their natural state from their state of tension, whenever the two electric forces are allowed to neutralize

themselves by some other channel, as by the interposition of a good conductor between the two coatings.

The Leyden jar.—The electrical battery.—Residual charge.

Electrical discharge by conduction, by disruption and by convection.

Electricity excited by other means than by friction, for example, by fracture, pressure, heating, crystallization and evaporation.

Thunder and lightning.—Aurora-borealis.

Magnetism.—Magnetic attraction and repulsion.—Magnetic induction.—Construction of magnets.—Direction and dipping needles.—Variations in the direction and dip.—Magnetic hypotheses.

Chemical affinity, is the force which occasions the union of different kinds of matter, whether simple or compound. The greater the opposition of properties in bodies, the stronger appears to be this species of attraction between them. Metallic bodies combine with non-metallic; acids with alkalies; combustible with non-combustible bodies.

Illustrations of this force from the bi-elementary combination of elements. Between some of the elements there is no disposition to unite.—Those elements which enter into union do so with variable degrees of attraction.—Change of properties consequent on chemical union.—The compounds of any two elements are few and never vary in their proportions.—If two elements combine in more than one proportion, the combining quantities bear some simple ratio to each other. “The proportions are always some simple multiples or sub-multiples of each other. Such variations of proportions admit of nothing intermediate, and they as completely constitute new species of matter as do the combinations of different elements.”

INORGANIC CHEMISTRY.

BINARY COMPOUNDS.—After the foregoing preliminaries to chemical investigations, we are prepared to enter directly upon the main business of the science, which consists in studying the composition of bodies and their mutual reactions. Those compounds which result from the union of but two elements, and hence called binary compounds, will first demand attention.

The order of succession in which they will be taken up, will appear after an explanation of the division of elements into the two groups, of supporters of combustion and combustibles.

Supporters of Combustion.

Names.					Chemical signs.
1. Oxygen,	-	-	-	-	O
2. Chlorine,	-	-	-	-	Cl
3. Bromine,	-	-	-	-	Br
4. Iodine,	-	-	-	-	I
5. Fluorine,	-	-	-	-	Fl

Physical properties of supporters of combustion.

Combustibles.

Names.	Signs.	Names.	Signs.
1. Nitrogen,	N	26. Nickel,	Ni
2. Hydrogen,	H	27. Arsenic,	As
3. Phosphorus,	P	28. Chromium,	Cr
4. Carbon,	C	29. Vanadium,	V
5. Sulphur,	S	30. Molybdenum,	Mo
6. Selenium,	Se	31. Tungsten,	W
7. Boron,	B	32. Columbium,	Ta
8. Silicon,	Si	33. Antimony,	Sb
9. Potassium,	K	34. Uranium,	U
10. Sodium,	Na	35. Cerium,	Ce
11. Lithium,	L	36. Lanthanium,	La
12. Barium,	Ba	37. Bismuth,	Bi
13. Strontium,	Sr	38. Titanium,	Ti
14. Calcium,	Ca	39. Tellurium,	Te
15. Magnesium,	Mg	40. Copper,	Co
16. Aluminium,	Al	41. Lead,	Pb
17. Glucinium,	G	42. Mercury,	Hg
18. Yttrium,	Y	43. Silver,	Ag
19. Zirconium,	Z	44. Gold,	Au
20. Manganese,	Mn	45. Platinum,	Pl
21. Iron,	F	46. Palladium,	Pd
22. Zinc,	Zn	47. Rhodium,	R
23. Cadmium,	Cd	48. Osmium,	Os
24. Tin,	Sn	49. Iridium,	Ir
25. Cobalt,	Co		

Physical properties of combustibles.

BINARY COMPOUNDS BETWEEN SUPPORTERS OF COMBUSTION.

Compounds of oxygen and chlorine.

Names and Composition.

	Chlorine.		Oxygen.		Sign.
Hypochlorous acid,	35.42	1 equiv. +	8	1 equiv. =	43.42 Cl + O
Chlorous acid,	35.42	1	" + 32	4	" = 67.42 Cl + 4O
Chloric acid,	35.32	1	" + 45	5	" = 75.42 Cl + 5O
Perchloric acid,	35.42	1	" + 56	7	" = 91.42 Cl + 7O

Explanation of chemical nomenclature.

Properties of hypochlorous acid. A transparent liquid. Odor like chlorine. Possesses bleaching properties. Suffers spontaneous decomposition.

Properties of chlorous acid. A bright yellowish green gas. Odor aromatic. Explodes violently when heated to 212° . Sets fire to phosphorus.

Properties of chloric acid. A colorless liquid of an oily consistence. Sour. Sets fire to paper. When sharply heated in a retort is converted into chlorine and oxygen.

Properties of perchloric acid. When concentrated its sp. gr. = 1.65. Boils at 392° .

Compound of oxygen and bromine.

	Bromine.		Oxygen.		Sign.
Bromic acid,	78.4	1 equiv. +	40	5 equiv. =	118.4 Br + 5O

Compound of oxygen and iodine.

Oxide of iodine, } composition undetermined.
Iodous acid, }

	Iodine.		Oxygen.		
Iodic acid,	126.3	1 equiv. +	40	5 equiv. =	166.3 I + 5O
Periodic acid,	126.3	1	" + 56	7	" = 182.3 I + 7O

Properties of oxide of iodine. A yellow oily solid.

" iodous acid. A yellow liquid.

" iodic acid. A white solid. Fuses at 500° , and is resolved into oxygen and iodine.

" periodic acid. At a heat above 212° begins to be resolved into iodic acid and oxygen.

Compound of nitrogen and phosphorus.

Phosphorus. Nitrogen.

Nitret of phospho. 15·7 1 equiv. + 14·15 1 equiv. = 29·75 N + P

Compound of nitrogen and carbon.

Carbon. Nitrogen.

Bi-carburet of ni- } 12·24 2 eq. + 14·15 1 eq. = 26·39 N + 2C
trogen, (cyanogen) }

Properties of cyanogen. Colorless gas. Sp. gr. = 1·815. Odor pungent. Becomes a liquid at 45° under a pressure of 3·6 atmospheres. Burns with a purple flame, but extinguishes burning bodies. Water at 60° absorbs 4·5 times, and alcohol 23 times its volume of the gas.

Compound of hydrogen and phosphorus.

Phosphorus. Hydrogen.

Phosphuretted hydrogen, 31·4 2 eq. + 3 3 eq. = 34·4 2P + 3H

Properties of phosphuretted hydrogen. Colorless gas. Odor offensive. Taste bitter. Spontaneously inflammable in common air, or in oxygen gas.

Compound of hydrogen and carbon.

Hydrogen. Carbon.

Light carburetted hydrogen, 2 2 eq. + 6·12 1 eq. = 8·12 2H + C
Olefiant gas, - 2 2 " + 12·24 2 " = 12·24 2H + 2C

Properties of light carburetted hydrogen (heavy inflammable air, the inflammable air of marshes). Formed abundantly in stagnant pools. Colorless gas. Sp. gr. = 0·5593. Extinguishes all burning bodies. Does not support respiration. Burns with a yellow flame.

Properties of olefiant gas. Colorless gas. Sp. gr. = 0·9852. Tasteless and odorless. Water absorbs one-eighth its volume. Extinguishes flame. Does not support respiration. Burns with a dense white light. Decomposed by a succession of electric sparks into charcoal and hydrogen, the latter occupying double the space of the gas from whence it was derived.

Compounds of hydrogen and sulphur.

Hydrogen. Sulphur.

Sulphuretted hydrogen, 1 1 eq. + 16 1 eq. = 17 S + H
Bi-sulphuretted hydrogen, 1 2 " + 32 2 " = 33 2S + H

Properties of sulphuretted hydrogen (hydro-sulphuric acid.) Colorless transparent gas. Sp. gr. = 1·1782. Odor fetid. Taste

slightly acid. Reddens vegetable blues. Poisonous. A mixture of $\frac{1}{800}$ th in the air proved fatal to a dog. Extinguishes burning bodies, but burns itself with a pale blue flame. Liquefied by a pressure of 7 atmospheres at a temperature of 50° . Water dissolves about three times its bulk of the gas.

Properties of bi-sulphuretted hydrogen. An oil-like, adhesive, brown liquid. Sp. gr. = 1.769. Smell and taste like sulphuretted hydrogen.

Compound of hydrogen and selenium.

Hydrogen. Selenium.

Selenuretted hydrogen, 1 1 equiv. + 39.6 1 equiv. = 40.6 H + Se

Properties of selenuretted hydrogen (hydro-selenic acid). Colorless gas. Odor fetid. Irritates powerfully the lining membrane of the nose. It is freely absorbed by water.

Compound of hydrogen and boron.

Borette hydrogen. Composition not determined. A gas.

Compound of hydrogen and potassium.

Hyduretted potassium. A gas.

Hydret of potassium. A grey solid substance.

Compound of hydrogen and arsenic.

Hydrogen. Arsenic.

Arseniuretted hydrogen, 3 3 eq. + 75.2 2 eq. = 78.4 2As + 3H

Properties of arseniuretted hydrogen. Colorless gas. Sp. gr. = 2.695. Odor of garlic. Instantly kills small animals. Water absorbs one-fifth its volume. Extinguishes burning bodies, but burns itself with a blue flame, depositing a film of metallic arsenic on cold surfaces held in the flame.

Compound of hydrogen and tellurium.

Hydrogen. tellurium.

Telluretted hydrogen, 1 1 equiv. + 64.2 1 equiv. = 65.2 Te + H

Properties of telluretted hydrogen, (hydro-telluric acid). A gas resembling hydro-sulphuric acid in odor. Absorbable by water, forming a claret-colored solution.

Compound of phosphorus and carbon.

Phosphuret of carbon. It probably consists of one equivalent of each element.

Properties of phosphuret of carbon. A soft, lemon yellow powder, which burns below a red heat.

Compound of phosphorus and potassium.

Phosphuret of potassium. A chocolate-brown solid. Takes fire in the air, and when thrown into water.

Compound of phosphorus and calcium.

"	"	aluminium.
"	"	zinc.
"	"	cadmium.
"	"	tin.
"	"	cobalt.
"	"	nickel.
"	"	arsenic.
"	"	copper.
"	"	lead.
"	"	silver.
"	"	gold.

Compound of carbon and sulphur.

Bisulphuret of carbon. Sul. $32 \cdot 2 + \text{carbon}, 6 \cdot 12 = 38 \cdot 32 \text{ C} + 2\text{S}$.

Properties of bisulphuret of carbon, (alcohol of sulphur). Prepared by passing the vapor of sulphur over red hot charcoal in a porcelain tube, and collecting the products in cold water. Colorless, transparent liquid. Sp. gr. = $1 \cdot 272$. Taste, acrid and pungent. Odor, nauseous. Boils at 110° . Highly inflammable.

Compounds of carbon and iron.

Graphite (plumbago, black-lead). Found in the mineral kingdom, and formed incidentally during the preparation of cast-iron. It contains from 5 to 10 p. c. of iron. The native, or mineral graphite, considered by most chemists as a mechanical mixture of carbon with iron; while artificial graphite is regarded as a strictly chemical compound.

Cast-iron of three kinds, black cast-iron, mottled cast-iron, and white cast-iron. Black cast-iron is imperfectly malleable, and can be turned on the lathe. It is easy to melt, and is much used for castings. It contains from 3 to $4 \cdot 6$ p. c. of carbon, of which only about one-quarter is intimately combined with the metal. Gray, or mottled cast-iron is harder than the black variety, but soft enough to be cut and bored. Sp. gr. = $7 \cdot 06$. Used for making cannon. White cast-iron has a silver white color, a fibrous or

crystalline structure. Sp. gr.=7.68. It is too hard to be bored or filed. It contains 5.2 p. c. of carbon, the whole of which is supposed to be intimately combined with the iron. Steel has a fine granular texture, is harder and more rigid than iron. Sp. gr.=7.7 to 7.8. It contains from 1.3 to 1.75 p. c. of carbon. Manufacture of steel, process of cementation. Blistered steel. Shear-steel. Cast-steel. Case-hardening.

Compound of sulphur and boron.

	Sulphur.	Boron.	
Sulphuret of boron,	16	1 equiv.	+ 10.9 1 equiv. = 26.9 S + B

Compound of sulphur and selenium.

Sesquisulphuret of selenium. Color deep orange. It softens at 212°, and may be distilled at a higher temperature.

Compound of sulphur and silicon.

	Sulphur.	Silicon.	
Sulphuret of silicon,	16	1 equiv.	+ 22.5 1 equiv. = 38.5 S + Si

Properties of sulphuret of silicon. A white earthy looking solid. Decomposed by a red heat and by moisture.

Combination of sulphur with the metals.—Formed, by heating the metal directly with sulphur. The metallic sulphurets are generally opaque, brittle, solid, presenting a variety of colors, and sometimes a metallic lustre. They are all fusible by heat, and nearly all insoluble in water.

Compounds of sulphur and potassium.

	Potassium.		Sulphur.	
Protosulphuret of potas.	39.15	1 eq.	+ 16	1 eq. = 55.25 K + 5
Bi-sulphuret	39.15	"	+ 32	2 " = 71.35 K + 2S
Tersulphuret	39.15	"	+ 28.3	3 " = 87.45 K + 3S
Quadrosulphuret	39.15	"	+ 64.4	4 " = 103.55 K + 4S
Quinquesulphuret	39.15	"	+ 80.5	5 " = 119.65 K + 5S

Properties of quinquesulphuret of potassium. Formed by fusing pearl-ashes, (carbonate of potassa,) with its own weight of sulphur. The fused mass contains sulphate of potassa mingled along with the quinquesulphuret of potassium, and constitutes the hepar-sulphuris. It has a liver-brown color, is hard, brittle, and breaks with a vitreous fracture. Taste bitter, acrid and caustic. Leaves a brown stain upon the skin.

Sulphuret of sodium.

Protosulphuret of barium.

“ strontium.

Sulphuret of calcium.

Sesquisulphuret of aluminium.

Protosulphuret of manganese. Sul. $16.1 + \text{mang. } 27.7 = 43.8$
 $\text{Mn} + \text{S}$. Found in the mineral kingdom, and called mangan-
 blende.

Protosulphuret of iron. Sul. $16.1 + \text{iron } 28 = 44.1$ $\text{Fe} + \text{S}$. A
 yellowish grey, brittle solid, with metallic lustre. Attracted by
 the magnet.

Sesquisulphuret of iron. Sul. $48.3 + \text{iron } 56 = 104.3$ $2\text{Fe} + 3\text{S}$.

Bisulphuret of iron. Sul. $32.2 + \text{iron } 28 = 60.2$ $\text{Fe} + 2\text{S}$.
 Abundant in the mineral kingdom, and known as iron-pyrites.
 Primary form, the cube. Strikes fire with steel. Sp. gr. = 4.981 .

A compound of 1 equivalent (60.2) of bisulphuret of iron, with
 5 equivalents (220.5) of protosulphuret of iron = 280.7 . Abundant
 in nature, and called magnetic iron-pyrites. Brittle. Sp. gr. =
 4.63 . Color bronze yellow.

Sulphuret of zinc. Sul. $16.1 + \text{zinc } 32.3 = 40.4$ $\text{Zn} + \text{S}$. An
 abundant mineral, known under the name of blende. Primary
 form of its crystal, the cube. Color, yellow, red, brown or black.
 Sp. gr. = 4.07 .

Sulphuret of cadmium. Sul. $16.1 + \text{cadmium, } 55.8 = 71.9$ Cd
 $+ \text{S}$. A native compound, called Greenockite, and which much
 resembles blende.

Protosulphuret of tin. Sul. $16.1 + \text{tin } 58.9 = 75$ $\text{Sn} + \text{S}$.

Sesquisulphuret of tin. Sul. $48.3 + \text{tin } 117.8 = 166.1$ $2\text{Sn} + 3\text{S}$.

Bisulphuret of tin. Sul. $32 + \text{tin } 58.9 = 91.1$ $\text{Sn} + 2\text{S}$. For-
 merly called Mosaic gold. In thin crystalline scales of a golden
 yellow color and metallic lustre.

Sulphurets of cobalt.

“ nickel.

Protosulphuret of arsenic. Sul. $16.1 + \text{arsenic } 37.7 = 53.8$.
 $\text{As} + \text{S}$. A mineral production known as realgar, which crystal-
 lizes in the form of the oblique rhombic prism. Sp. gr. = 3.56 .
 Color, aurora-red. Soft.

Sesquisulphuret of arsenic. Sul. $48\cdot3 + \text{arsenic } 75\cdot4 = 123\cdot7$. $2\text{As} + 3\text{S}$. Known as orpiment in the mineral kingdom. In crystals, and curved lamellar masses. Sp. gr. $= 3\cdot48$. Color, lemon-yellow. Soft. Used as a pigment under the name of king's yellow.

Sesquisulphuret of chromium. Sul. $48\cdot3 + \text{chrom. } 56\cdot2 = 104\cdot3$. $2\text{Cr} + 3\text{S}$.

Bisulphuret of vanadium.

Tersulphuret of vanadium.

Bisulphuret of molybdenum. Sul. $32\cdot2 + \text{molyb. } 47\cdot7 = 79\cdot9$. $\text{Mo} + 2\text{S}$. The molybdenite of mineralogists. In hexagonal plates and foliated masses of a lead-grey color and metallic lustre. Soft. Sp. gr. $= 4\cdot59$.

Tersulphuret of molybdenum.

Persulphuret of molybdenum.

Bisulphuret of tungsten.

Tersulphuret of tungsten.

Sulphuret of columbium.

Sesquisulphuret of antimony. Sul. $48\cdot3 + \text{antim. } 129\cdot2 = 177\cdot5$. $2\text{Sb} + 3\text{S}$. The usual ore of antimony, called grey antimony. In right rhombic prisms of $91^\circ 10'$. Color, lead-grey. Lustre, metallic. Soft. Sp. gr. $= 4\cdot62$.

Bisulphuret of antimony.

Persulphuret of antimony. Sul. $80\cdot5 + \text{antim. } 129\cdot2 = 209\cdot7$. $2\text{Sb} + 5\text{S}$. Formed by the action of hydrosulphuric acid on a solution of antimonious acid, or by boiling grey antimony and sulphur with a solution of potassa. It is called the golden sulphuret of antimony.

Oxysulph. $\left\{ \begin{array}{l} \text{Sesquisulph. } 355\cdot \\ \text{antimony. } \end{array} \right\} \left\{ \begin{array}{l} 2 \text{ eq. } \\ 1 \text{ eq. } \end{array} \right\} = 508\cdot2 \left\{ \begin{array}{l} 2\text{Sb}^2\text{S}^3 \\ + \text{Sb}^2\text{O}^3 \end{array} \right\}$

It occurs in the mineral kingdom, and is known by the name of red antimony. Crystal, right rhombic prism of $101^\circ 19'$. Color, cherry-red. Sp. gr. $= 4\cdot49$. The pharmaceutic compounds, denominated glass of antimony, liver of antimony, and crocus of antimony, resemble the red antimony in composition, with the exception of the vitreous matter they derive in their preparation from the earthen crucibles in which they are prepared. The process for forming them consists, in roasting the grey antimony in earthen

crucibles, so as to form sulphurous acid and sesquioxide of antimony, and then by means of a strong heat vitrifying the oxide, together with undecomposed ore. The products vary also, according as more or less of the sulphuret escapes oxidation during the process.

✓ **Kermes mineral**,—processes for, as follows: 1. Boil grey antimony in a solution of potassa or soda; when the liquid cools, it throws down the kermes. 2. Ignite grey antimony with carbonate of potassa or soda, and treat the fused mass with hot water. 3. Boil for three fourths of an hour, four parts grey antimony, 90 crystallized carbonate of soda and 1000 of water: the filtered solution throws down the kermes after 24 hours, which must be moderately washed with cold water and dried at 70° or 80° . According to **BERZELIUS** and **ROSE**, the kermes differs from the grey antimony, only in being combined with water, the sesquioxide of antimony found with it being an ingredient which is mechanically associated rather than chemically combined.

Sulphuret of uranium.

Sulphuret of cerium.

Sulphuret of bismuth. Sul. $16\cdot1 + \text{bismuth}, 71 = 87\cdot1 \text{ Bi} + \text{S}$. The bismuthine of mineralogists. Crystal, right rhombic prism of 91° . Color, lead-grey. Lustre, metallic. Sp. gr. = $6\cdot54$.

Bisulphuret of titanium.

Bisulphuret of tellurium. Sul. $32\cdot2 + \text{tel. } 64\cdot2 = 96\cdot4$.

Persulphuret of tellurium.

Disulphuret of copper. Sul. $16\cdot1 + \text{copper}, 63\cdot2 = 79\cdot3 \text{ 2Cu} + \text{S}$. The vitreous copper of the mineral kingdom. Primary form, right rhombic prism of $119^{\circ} 35'$. Easily cut with a knife. Sp. gr. = $5\cdot69$. Color, blackish lead-grey. Lustre, metallic.

Protosulphuret of copper. Sul. $16\cdot1 + \text{cop. } 31\cdot6 = 47\cdot7 \text{ Cu} + \text{S}$.

Sulphuret of lead. Sul. $16\cdot1 + \text{lead}, 103\cdot6 = 119\cdot8 \text{ Pb} + \text{S}$. The most abundant ore of lead, and known under the mineralogical name of galena. Primary form, the cube. Easily cut with a knife. Sp. gr. = $7\cdot56$. Color, lead-grey. Lustre, metallic.

Protosulphuret of mercury. Sul. $16\cdot1 + \text{mercury}, 202 = 218\cdot1 \text{ Hg} + \text{S}$. Color, black.

Bisulphuret of mercury. Sul. $32\cdot2 + \text{mercury}$, $404 = 436\cdot2$ $\text{Hg} + 2\text{S}$. The common ore of mercury, and known by the name of cinnabar. Primary form, a rhomboid of 72° . Easily cut with the knife. Color, cochineal-red. Sp. gr. $= 8\cdot09$. The artificially prepared variety is called, when pulverized, vermilion.

Sulphuret of silver. Sul. $16\cdot1 + \text{sil. } 108 = 124\cdot1$ $\text{Ag} + \text{S}$. The vitreous silver of the mineral kingdom, a valuable ore of silver. Primary form, a cube. Malleable. Color, blackish lead-grey. Sp. gr. $= 7\cdot19$.

Tersulphuret of gold.

Protosulphuret of platinum.

Bisulphuret of platinum.

Protosulphuret of palladium.

Sulphuret of rhodium.

Sulphuret of osmium.

Combination of selenium with the metals.—The metallic seleniurets resemble the sulphurets very closely in their chemical and physical relations.

Seleniurets of potassium.

Seleniuret of iron.

“ tin.

“ copper.

“ lead.

“ mercury.

“ silver.

Combinations of boron with the metals.

Boret of iron.

“ platinum.

Combinations of silicon with the metals.

Silicet of potassium.

“ iron.

Combinations of arsenic with other metals.

Arseniet of manganese. Found in the mineral kingdom. Hard, brittle, fine granular mineral. Color greyish white. Sp. gr. $= 5\cdot5$.

Arseniet of iron? Arsen. $37\cdot7 + \text{iron } 38 = 65\cdot7$ $\text{Fe} + \text{As}$.

Binarseniet of cobalt. A valuable ore of cobalt, called cobaltine. Primary form, the cube. Hard. Sp. gr. $= 6\cdot29$. Color silver white. Lustre metallic.

Arseniet of nickel. The most frequent ore of nickel, and known under the name of copper-nickel. Color pale copper-red. Sp. gr.=7.65.

Arseniet of copper.

Combinations of antimony with other metals.

Antimoniet of copper. Called the regulus of Venus by the alchymists.

Antimoniet of silver. Antimonial silver-ore. Color tin-white. Lustre metallic. Sp. gr.=9.4.

Combinations of tellurium with other metals.

Telluret of bismuth. An ore, called bornite. Sp. gr.=8.

Telluret of silver. An ore, called telluric silver. Sp. gr.=8.4. Color lead-grey. Lustre shining.

Alloys, analogous to metals in their physical properties.—They often differ in color, hardness, malleability, and fusibility, from the elements of which they consist.*

Amalgams.—Amalgam of potassium. (Amalgam of tin,—used in silvering looking-glasses.) Amalgam of zinc and tin,—used for promoting the action of the electrical machine. Amalgam of silver. Found in the mineral kingdom, and known under the name of native amalgam. Primary form, the cube. Color silver-white. Sp. gr.=13.7. Consists of one equivalent of silver + two of mercury. (Application of the affinity between silver and mercury to the separation of silver from its ores.)—An amalgam of silver is used for silvering wire of the inferior metals. An amalgam of one part gold and eight of silver is employed in gilding brass.

Alloys of arsenic. Arsenic renders the metals with which it is alloyed, brittle and fusible. It destroys the color of copper and gold. Copper with $\frac{1}{16}$ th arsenic is very similar to silver. The presence of arsenic in iron renders it brittle.

Alloys of tin, lead, antimony and bismuth. (Two parts of tin and one of lead form soft solder.) It fuses at 360° ; 3 lead and 1 tin form coarse solder: it fuses at 500° . Tin and zinc, or tin and antimony form pewter. The best kinds have small addi-

* In treating of alloys here, we do not confine our attention solely to such as consist of two elements, but describe the class generally.

tions of copper and bismuth; inferior sorts have a large proportion of lead; 8 parts of bismuth, 5 of lead, and 3 of tin, form an alloy which melts at 212° : 2 of bismuth, 1 of lead, and one of tin, another, which melts at 200° . Type-metal consists of 3 parts lead, and 1 of antimony.

Alloys of copper. One equivalent of copper 63.5 with one equivalent of zinc 32.3, constitutes brass. Equal weights of these metals afford the variety of brass known by the names of Prince's metal, pinchbeck, and Manheim gold. Mosaic gold is formed from 100 copper and 53 zinc: Bath-metal from 32 brass and 9 zinc: the platin of button manufacturers from 8 brass and 5 zinc. Red brass or tombac has more copper and less zinc than brass. Dutch foil consists of 11 copper, and 2 zinc. Bronze is an alloy of copper and tin, to which a little zinc or lead is sometimes added. It is much harder than copper, and more fusible. Cannon-metal bronze consists of 90 copper and 10 tin. Bronze ornaments of 82 copper, 18 zinc, 3 tin, and 1 lead. Bronze for bells, of 78 copper and 22 tin. Some bells admit 5 to 6 p. c. of zinc, and 3 to 4 p. c. of lead. Vessels of copper used in cooking are usually protected on the inside by a thin coating of tin. A vessel 9 inches across, by 3 deep, requires but 21 grains of tin in the process. German silver, (argentane,) or white copper is formed from 40 copper, 25 zinc, 31 nickel, and 2 iron.

Alloys of silver. Copper does not alter the color of silver, except in very large quantity, but it increases its hardness. Silver coin usually contains about $\frac{1}{13}$ its weight of copper. Steel with $\frac{1}{500}$ th silver is superior to the best cast-steel.

Alloys of gold. Gold with $\frac{1}{920}$ th of lead has its malleability much diminished. A very small proportion of copper changes the color of gold to a red tint. Gold coin contains about $\frac{1}{2}$ its weight of copper.

BINARY COMPOUNDS BETWEEN SUPPORTERS AND COMBUSTIBLES.

Compounds of oxygen and nitrogen.

	By volume.		By weight.		Equiv.
	Nitr.	Oxy.	Nitr.	Oxy.	
Protoxide of nitrogen,	2	1	14.15 + 8 =	22.15	N + O
Binoxide of nitrogen,	2	2	14.15 + 16 =	30.15	N + 2O
Hyponitrous acid,	2	3	14.15 + 24 =	38.15	N + 3O
Nitrous acid,	2	4	14.15 + 32 =	46.15	N + 4O
Nitric acid,	2	5	14.15 + 40 =	54.15	N + 5O

Properties of protoxide of nitrogen (nitrous oxide). Colorless gas. Sp. gr.=1.52. Water at 60°, absorbs its bulk of this gas. The solution like the gas, has a faintly sweet taste. It supports combustion more vividly than common air. It supports respiration for a few minutes, producing agreeable feelings of excitement.

Properties of binoxide of nitrogen, (nitric oxide, deutoxide of nitrogen). Colorless gas. Sp. gr.=1.037. Water absorbs about $\frac{1}{10}$ th its bulk of this gas. Irrespirable; mingled with oxygen it produces dense orange-red vapors, called nitrous acid vapors, which are rapidly absorbed by water. Extinguishes most burning bodies, unless in a state of vivid combustion, when it vehemently promotes their inflammation.

Properties of hyponitrous acid. An orange colored gas which becomes a green liquid at 0° of a sp. gr.=1.72. In open vessels, it rapidly passes off in the form of an orange vapor.

Properties of nitrous acid. Mix 200 measures of binoxide of nitrogen with 100 of oxygen gas in a previously exhausted dry glass vessel. The product is an orange-red vapor. Sp. gr.=3.177. Irrespirable. Supports combustion. It is condensed into a liquid by a freezing mixture. The anhydrous liquid acid at common temperature, is orange-red; but it becomes yellow at 32° and colorless at 0°. Sp. gr.=1.451. Boils at 82°.

Properties of nitric acid. May be formed by passing electric shocks through a mixture of nitrogen and oxygen gases standing over a little water, or by adding binoxide of nitrogen slowly to oxygen over water. Nitric acid cannot exist in an insulated state. It is prepared by decomposing a compound of nitric acid and potassa, nitre, by means of sulphuric acid. The aqueo-nitric acid which is distilled off by the heat employed, condenses in the receiver of the apparatus.

Table of strength and boiling points of nitric acid.

Sp. gr.	Acid in 100 parts.	Sp. gr. of acid.	Boiling point.
1.2012	- 28.571	1.14	- 219
1.2173	- 30.500	1.15	- 219
1.2334	- 31.579	1.16	- 220
1.2495	- 32.574	1.17	- 221
1.2656	- 35.294	1.18	- 223
1.2844	- 37.500	1.20	- 226

Sp. gr.		Acid in 100 parts.	Sp. gr. of acid.		Boiling point.
1.3032	-	40.000	1.22	-	229
1.3220	-	42.857	1.26	-	232
1.3456	-	46.200	1.30	-	236
1.3692	-	50.000	1.35	-	242
1.3928	-	54.545	1.40	-	247
1.4237	-	60.000	1.42	-	248
1.4546	-	66.668	1.45	-	240
1.4855	-	75.000	1.50	-	210
1.5500	-	85.714	1.54	-	175

When the vapor of nitric acid is passed through red hot porcelain tubes, it is decomposed into a mixture of oxygen and nitrogen gases. The nitric acid has a faint agreeable odor, and emits a white smoke. It is intensely sour, and corrodes animal and vegetable substances with great energy. The strong acid is less painful when applied to ulcers, than that which is more dilute. Aqua fortis, or single nitric acid, is obtained by distilling a mixture of nitre and copperas in cast iron retorts, luted to large green glass receivers. Its sp. gr. = 1.22, and is generally contaminated by the presence of muriatic acid.

Composition of atmospheric air. By volume, 4 of nitrogen to 1 of oxygen. Atmospheric air a mechanical mixture and not a chemical compound.

Compounds of oxygen and hydrogen.

	By volume.		By weight.	
	Hyd.	Oxy.	Hyd.	Oxygen.
Protox. of hyd. (water)	2	2	1 or 1 eq.	+ 8 or 1 eq. = 9 H + O
Peroxide of hydrogen,	1	1	1	+ 16 or 2 " = 17 H + 2O

Properties of water. Synthesis of water. Eudiometry. Analysis of water.

Properties of peroxide of hydrogen. A colorless transparent fluid. Sp. gr. = 1.452. It whitens the surface of the skin, and soon destroys its texture. At 59° it is converted into its water and oxygen gas.

Compounds of oxygen and phosphorus.

Oxides of phosphorus. When phosphorus is exposed in a long narrow tube to a heat of 212°, an oxide rises in the form of vapor and lines the tube with white flakes. Another oxide is formed

when phosphorus is long acted upon by water. It invests the sticks of phosphorus as a white coating: and a third combination occurs in the red residuum after the combustion of phosphorus in air-jars; or it may be formed by directing a stream of oxygen gas upon phosphorus kept melted under water.

	Phosphorus.	Oxygen.	
Phosphorous acid,	31.4	2 eq. + 24 or 3 eq. = 55.4	2P + 3O
Phosphoric acid,	} 31.4	2 " + 40 or 5 " = 71.4	2P + 5O
Pyrophosph. acid,			
Metaphosph. acid,			

Properties of phosphorous acid. A crystallizable compound of a sour taste, and very soluble in water. By heat, it is resolved into phosphuretted hydrogen and phosphoric acid.

Properties of phosphoric acid. Intensely sour. Its solution may be evaporated without decomposition at a temperature of 300° , when it assumes a dark color, becomes syrupy; and consists of 71.4 or one equivalent of acid, and 27 or three of water. On heating this hydro-phosphoric acid for several days to 415° it loses nearly two thirds of an equivalent of water; and then principally consists of pyrophosphoric acid, with two equivalents of water. At a red heat, it is converted into metaphosphoric acid, which is known also under the name of glacial phosphoric acid. This acid is rapidly deliquescent, and on becoming supplied with water it returns to the state of hydro-phosphoric acid.

Compounds of oxygen and carbon.

	Carbon.	Oxygen.	
Carbonic oxide, - -	6.12 +	8. = 14.12	C + O
Carbonic acid, - -	6.12 +	16. = 22.12	C + 2O

Properties of carbonic oxide. Colorless gas. Sp. gr. = 0.972. Does not support life or combustion, but burns with a blue flame.

Properties of carbonic acid. Colorless, and inodorless gas. Sp. gr. = 1.52. Extinguishes all burning bodies. An animal cannot live in air which contains so much of the gas as to put out a lighted taper. It is wholly incombustible. Recently boiled water at common temperature and pressure, absorbs its volume of this gas, but more, if the pressure be increased. Carbonic acid in the air, in waters, and in the earth.

Compounds of oxygen and sulphur.

		Sulphur.	Oxygen.	
Sulphurous acid,	-	16·1	+ 16=32·1	S+2O
Sulphuric acid,	-	16·1	+ 24=40·1	S+3O
Hyposulphurous acid,	-	32·2	+ 16=48·2	2S+2O
Hyposulphuric acid,	-	32·2	+ 40=72·2	2S+5O

Properties of sulphurous acid. A pungent, suffocating, colorless gas. Sp. gr.=2·21. Extinguishes all burning bodies; is not inflammable, nor does it support respiration, but causes violent irritation and spasm of the glottis. Its taste is acid. It exerts considerable bleaching power. Water dissolves 33 times its volume of this gas. The gas becomes liquefied at 45°, under the pressure of two atmospheres; and under one atmosphere, at 0°. The sp. gr. of the liquid=1·45, and it boils at 14°. Sulphurous acid gas a product of volcanoes.

Properties of sulphuric acid (oil of vitriol). A colorless fluid. Sp. gr.=1·85. A powerfully corrosive acid, decomposing all animal and vegetable substances. It has a strong attraction for water, the combination taking place with intense heat. An acid of sp. gr.=1·85, contains about 81 per cent. of real acid, and 18 per cent. water. It boils at 620° and freezes at 15°. If diluted with water to a sp. gr.=1·78, it crystallizes at 32°, and remains solid at 45°. Sulphuric acid found in the mineral kingdom.

Properties of hyposulphurous acid. It cannot exist permanently in a free state.

Properties of hyposulphuric acid. It cannot be obtained free from water. It may be concentrated to a sp. gr.=1·34.

Compounds of oxygen and selenium.

		Selenium.	Oxygen.	
Protoxide of selenium,	-	39·6	+ 8=47·6	Se+O
Selenious acid,	-	39·6	+ 16=55·6	Se+2O
Selenic acid,	-	39·6	+ 24=63·6	Se+3O

Properties of protoxide of selenium. A colorless gas, sparingly soluble in water: odor fetid.

Properties of selenious acid. Crystallizes in slender needles, which are soluble in water.

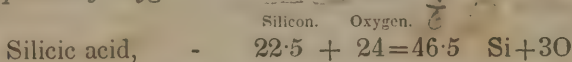
Properties of selenic acid. Colorless liquid. Concentrated by a heat of 329° its sp. gr.=2.52, at 512° its sp. gr.=2.60. Decomposed by heat at 554° . Resembles sulphuric acid.

Compound of oxygen and boron.



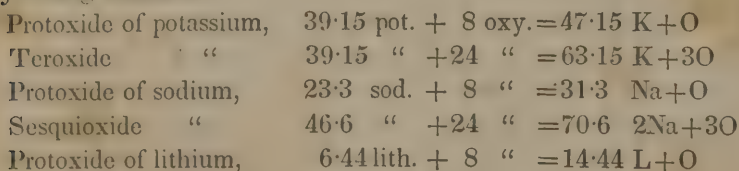
Properties of boric acid (boracic acid). A hard, colorless, transparent substance. Sp. gr.=1.80. Exceedingly fusible, and imparts fusibility to other bodies. It has a strong affinity for water, with which it unites to form a crystalline hydrate in the ratio of 1 equivalent of acid to 3 of water, i. e. of 34.9 acid to 27 water. Its sp. gr.=1.479. It is soluble in water and alcohol. The alcoholic solution burns with a beautiful green color. Boric acid is found sublimed in crevices of volcanoes, and dissolved in the hot springs of the Florentine territory.

Compound of oxygen and silicon.



Properties of silicic acid, (silica). A light white powder, which feels harsh and rough between the fingers. Insipid and inodorous. Sp. gr.=2.69. Infusible in the fire and insoluble in water after having been ignited, but soluble when presented in the nascent state to water. Abundant in the mineral kingdom under the names of quartz, flint, agate, opal, pitchstone, siliceous sand, &c.

Compounds of oxygen with potassium, sodium, and lithium,—forming alkalis.



Properties of protoxide of potassium, (potassa). A white solid. Fuses, when heated rather above redness. Strong affinity for water, with which it forms three definite compounds,—one consisting of one equivalent of water with one of potassa, a second of three of water, and a third of five of water to one of potassa. The

protohydrate of potassa is solid at common temperatures, fuses rather below redness, and assumes a crystalline texture in cooling. Sp. gr.=1.70. Highly deliquescent, and requires but half its weight of water for solution. It is soluble also in alcohol. It is a powerful caustic, and was formerly called the lapis causticus, but is now denominated the potassa fusa. Decomposed, by bringing it in the melted state in contact with the turnings of iron, heated to whiteness in a gun-barrel: the iron deprives the water and potassa of oxygen, hydrogen gas combined with a little potassium is evolved; and pure potassium sublimes and concretes upon a cool part of the apparatus.

Properties of the protoxide of sodium, (soda). A grey solid, difficult to melt, and much resembling potassa. Deliquescent. With water it forms a solid hydrate, composed of one equivalent of soda (31.3) and one equivalent of water (9.)

Properties of protoxide of lithium (lithia). Like potassa and soda, it is strongly alkaline, and forms with water an hydrate. Does not deliquesce.

Compounds of oxygen with barium, strontium, calcium, and magnesium,—forming alkaline earths.

Protoxide of barium,	68.7	bar.	+ 8oxy.	=76.7	Ba+O
Peroxide of barium,	68.7	"	+16 "	=84.7	Ba+2O
Protoxide of strontium,	43.8	stront.	+ 8 "	=51.8	Sr+O
Peroxide of strontium,	43.8	"	+16 "	=59.8	Sr+2O
Protoxide of calcium,	20.5	cal.	+ 8 "	=28.5	Ca+O
Peroxide of calcium,	20.5	"	+16 "	=36.5	Ca+2O
Protoxide of magnesium,	12.7	mag.	+ 8 "	=20.7	Mg+O

Properties of protoxide of barium, (baryta). A grey powder. Sp. gr.=4. It has a strong affinity for water, forming with it a solid proto-hydrate, and evolving during the combination, an intense heat. The hydrate dissolves in three times its weight of water at 212°, and 20 times, at 60°. The solution has a sharp caustic taste, and is poisonous.

Properties of protoxide of strontium, (strontita). Resembles baryta. Forms a solid proto-hydrate, which fuses at a red heat. Soluble in 50 times its weight of water at 60°, and in twice its weight at 212°. The hot solution throws down crystals on

cooling, which contain nine equivalents of water to one of strontita.

Properties of protoxide of calcium, (lime). A brittle, white earthy solid. Sp. gr.=2.3. Very difficult to fuse. In combining with water to form an hydrate, intense heat is evolved; the lime enlarges three times its bulk, and falls to powder, forming what is called slacked lime. Hydrate of lime requires 780 times its weight of water at 60° for solution, and 1270 times at 212° . Lime water has a harsh, acrid taste, and is strongly alkaline.

Properties of protoxide of magnesium, (magnesia). A white friable powder, without taste or odor. Sp. gr.=2.3. Very infusible. Forms with water an hydrate, which requires for solution 5142 times its weight of water at 60° , and 36,000 times at 212° . The hydrate of magnesia is found in the mineral kingdom.

Compounds of oxygen, aluminium, glucinum, yttrium, thorium, and zirconium,—forming earths.

Sesquioxide of aluminium, $27.4 \text{ alum.} + 24 \text{ oxy.} = 51.4 \text{ } 2\text{Al} + 3\text{O}$

“ glucinum, $53.0 \text{ gluc.} + 24 \text{ “} = 77. \text{ } 2\text{G} + 3\text{O}$

Protoxide of yttrium, $32.2 \text{ ytt.} + 8 \text{ “} = 40.2 \text{ } \text{Y} + \text{O}$

Oxide of thorium, composition unknown = 67.6

Sesquioxide of zirconium, $67.4 \text{ zir.} + 24 \text{ oxy.} = 91.4 \text{ } 2\text{Zr} + 3\text{O}$

Properties of sesquioxide of aluminium, (alumina.) Tasteless, odorless, white powder; very infusible and insoluble in water. It attracts water from the atmosphere with avidity. When once moistened, requires a full white heat to render it anhydrous. Found in the mineral kingdom in the species corundum, gibbsite, &c.

Properties of sesquioxide of glucinum, (glucina). A white tasteless powder. Sp. gr.=3.

Properties of protoxide of yttrium, (yttria). A white tasteless powder.

Properties of oxide of thorium, (thorina). A snow-white powder.

Properties of sesquioxide of zirconium, (zirconia). A grey powder. Sp. gr.=4.3.

Combination of oxygen with the metals,—producing metallic oxides and acids.

Phenomena of oxidation.—Reduction of metallic oxides to the metallic state.

Table of oxygen-compounds with metals which decompose water at a red heat.

Protoxide of manganese,	27.7	mang.	+ 8ox.	= 35.7 Mn+O
Sesquioxide	"	55.4	" + 24 "	= 79.4 2Mn+3O
Binoxide	"	27.7	" + 16 "	= 43.7 Mn+2O
Manganic acid,	27.7	"	+ 24 "	= 51.7 Mn+3O
Permanganic acid,	55.4	"	+ 56 "	= 111.4 2Mn+7O
Protoxide of iron,	28.	iron	+ 8 "	= 36. Fe+O
Sesquioxide of iron,	56.	"	+ 24 "	= 80. 2Fe+3O
Protoxide of zinc,	32.3	zinc	+ 8 "	= 40.3 Zn+O
Peroxide of zinc, composition unknown.				
Protoxide of cadmium,	55.8	cadmium	+ 8 "	= 63.8 Cd+O
Protoxide of tin,	58.9	tin	+ 8 "	= 66.9 Sn+O
Sesquioxide "	117.8	"	+ 24 "	= 141.8 Sn+3O
Binoxide "	58.9	"	+ 16 "	= 24.9 Sn+2O
Protoxide of cobalt,	29.5	cobalt	+ 8 "	= 37.5 Co+O
Sesquioxide of "	59.	"	+ 24 "	= 83. 2Co+3O
Protoxide of nickel,	29.5	nickel	+ 8 "	= 37.5 Ni+O
Sesquioxide "	59.5	"	+ 24 "	= 83. 2Ni+3O

Properties of protoxide of manganese. A light green powder; at a low red heat, is converted into red oxide of manganese, (a compound of one equivalent of protoxide of manganese and one of sesquioxide of manganese).

Properties of sesquioxide of manganese. A brownish black powder. Found in combination with water in the mineral called manganite. Primary form, right rhombic prism of $99^{\circ} 40'$. Lustre, sub-metallic. Sp. gr.=4.32.

Properties of binoxide of manganese. Found abundantly in the mineral kingdom, and known under the name of pyrolusite, or black oxide of manganese. Sometimes occurs in small crystals, but generally massive, in reniform coats and stalactitic masses. Color, iron black. Sectile. Sp. gr.=4.8. When exposed for a considerable time to a red heat, it gives up half an equivalent of oxygen, and passes to the condition of the sesquioxide of manganese. Every 42.7 grs. of the binoxide will lose 4 grs. of

oxygen, or nearly 12 cubic inches: one oz. will therefore yield, if pure, about 128 cubic inches of gas.

Protoxide of iron. Never obtained pure in an insulated form.

Properties of sesquioxide of iron. A red powder when obtained artificially; but it is one of the most abundant of all the ores of iron, being found in a state of purity in the mineral species, called specular iron, (red hæmatite). Crystals derived from a rhomboid of $86^{\circ} 10'$. Lustre, metallic. Color, dark grey to black. Powder, red. Brittle. Sp. gr.=5.25. It also exists in the condition of hydrated sesquioxide of iron, (one equivalent of peroxide of iron + one of water). Known also under the name of limonite, (brown hæmatite and bog iron ore,) and combined along with the protoxide of iron in the well known ore of magnetic iron, which consists of one equivalent protoxide + one of sesquioxide of iron. The color of this ore is iron black, the primary form of its crystal is the cube. Brittle. Sp. gr.=5.09.

Manufacture of bar-iron from its ores.

Properties of protoxide of zinc. A white powder, which becomes yellow when heated to redness.

Properties of protoxide of cadmium. An orange yellow powder, remains fixed in the fire.

Properties of protoxide of tin. A white powder. Sp. gr.=6.66. At a red heat, it absorbs oxygen from the air, and becomes binoxide of tin.

Properties of the binoxide of tin. A straw-yellow powder. Found crystallized in the mineral kingdom, and known under the name of tin-ore. Primary form, a right square prism. Color, brown. Lustre, adamantine. Brittle. Sp. gr.=6.96.

Properties of protoxide of cobalt. An ash grey powder: heated to redness, becomes sesquioxide of cobalt.

Properties of protoxide of nickel. An ash-grey powder, which changes to olive-green on being heated to whiteness.

Table of oxygen-compounds with metals which do not decompose water at any temperature, and the oxides of which are not reduced to the metallic state by the sole action of heat.

Arsenious acid,	75.4 arsen. + 24 oxy. = 99.4 2As + 3O
Arsenic acid,	75.4 " + 40 " = 115.4 2As + 5O

Sesquioxide of chromium,	56·	chrom.	+24 oxy.	= 80·	2Cr+3O
Chromic acid,	28·	"	+24 "	= 52·	Cr+3O
Protoxide of vanadium,	68·5	van.	+ 8 "	= 76·5	V+O
Binoxide "	68·5	"	+16 "	= 84·5	V+2O
Vanadic acid,	68·5	"	+24 "	= 92·5	V+3O
Protox. of molybdenum,	47·7	mol.	+ 8 "	= 55·7	M+O
Binoxide "	47·7	"	+16 "	= 63·7	M+2O
Molybdic acid,	47·7	"	+24 "	= 71·7	M+3O
Binoxide of tungsten,	94·8	tungs.	+16 "	=110·8	W+2O
Tungstic acid,	94·8	"	+24 "	=118·8	W+3O
Binoxide of columbium,	185·	col.	+16 "	=201·	Ta+2O
Columbic acid,	185·	"	+24 "	=209·	T+3O
Sesquioxide of antimony,	129·2	antim.	+24 "	=153·2	2Sp+3O
Antimonious acid,	129·2	"	+32 "	=161·2	2Sp+4O
Antimonic acid,	129·2	"	+40 "	=169·2	2Sp+5O
Protoxide of uranium,	217·	uran.	+ 8 "	=225·	U+O
Sesquioxide "	434·	"	+24 "	=458·	2U+3O
Protoxide of cerium,	46·	cer.	+ 8 "	= 54·	Ce+O
Sesquioxide "	92·	"	+24 "	=116·	2Ce+3O
Oxide of lantium.					
Protoxide of bismuth,	71·	bis.	+ 8 "	= 79·	Bi+O
Sesquioxide "	142·	"	+24 "	=166·	2Bi+3O
Protoxide? titanium,	24·3	titan.	+ 8 "	= 32·3	Ti+O
Titanic acid,	24·3	"	+16 "	= 40·3	Ti+2O
Tellurous acid,	64·2	tellur.	+16 "	= 80·2	Te+2O
Telluric acid,	64·2	"	+24 "	= 88·2	Te+3O
Dioxide of copper,	63·2	cop.	+ 8 "	= 71·2	2Cu+O
Protoxide "	31·6	"	+ 8 "	= 39·6	Cu+O
Binoxide "	31·6	"	+16 "	= 47·6	Cu+2O
Dioxide of lead,	207·2	lead,	+ 8 "	=215·2	2Pb+O
Protoxide "	103·6	"	+ 8 "	=111·6	Pb+O
Binoxide "	103·6	"	+16 "	=119·6	Pb+2O

Properties of arsenious acid, (white arsenic). Found in small quantity in the mineral kingdom, and is generated whenever arsenic is heated above 356° in the open air. Color white. Sp. gr.=3·7. Volatilized at 380° , and is deposited on cold surfaces in small octahedral crystals. Taste sweetish. Poisonous. 1000 parts of boiling water dissolve from 97 to 115 of arsenious acid, and retain when cold from 18 to 29 parts.

Properties of arsenic acid. Irregular white grains. When heated strongly, it is resolved into oxygen and arsenious acid. An active poison.

Method of testing for arsenic by the black-flux. Method by sulphuretted hydrogen and the black-flux. Method by arsenuretted hydrogen and the tache.

Properties of sesquioxide of chromium. A greenish black powder, having a strong metallic lustre. Sp. gr.=5.2. Fused with vitreous substances, it imparts to them an emerald-green color.

Properties of chromic acid. Very soluble in water; red when the solution is concentrated, yellow when dilute. Sour. It is converted into sesquioxide and oxygen, on the application of a strong heat.

Properties of protoxide of vanadium. Black crystalline grains, with a semi-metallic lustre. Infusible. Heated in an open vessel, it takes fire and burns like tinder, being converted into the binoxide.

Properties of binoxide of vanadium. A black pulverulent substance, infusible and insoluble in water. When heated in the open air, it is converted into vanadic acid.

Properties of vanadic acid. Color dark-red, with a shade of orange, and a strong lustre. It fuses at a heat below redness, and crystallizes in cooling. It is tasteless; insoluble in alcohol, and but slightly so in water.

Properties of protoxide of molybdenum. A black powder, which on being heated to redness takes fire, and is converted into the binoxide.

Properties of the binoxide of molybdenum. A deep brown powder.

Properties of molybdic acid. A white powder. Sp. gr.=3.49. Fuses at a red heat into a yellow liquid. Heated in an open vessel it rises and collects on cold surfaces in crystalline scales. It requires 570 parts of water for the solution of one part molybdic acid.

Properties of binoxide of tungsten. A blackish powder; on heating to redness, takes fire and becomes tungstic acid.

Properties of tungstic acid. A yellow powder, insoluble in water.

Properties of binoxide of columbium. A dark grey powder.

Properties of columbic acid. A tasteless, white powder, insoluble in water and infusible.

Properties of sesquioxide of antimony. Found in the mineral kingdom, and known as white antimony. Crystallizes in right rhombic prisms of $136^{\circ} 58'$. Sectile. Sp. gr. = 5.5. When artificially prepared, is a white powder, which assumes a yellow tint on being heated. It is very volatile, and may be sublimed without change.

Properties of antimonious acid. White, while cold; but acquires a yellow tint, when heated. It is infusible and fixed in the fire. Insoluble in water. The pulvis antimonialis (antimonial powder), prepared by burning together sulphuret of antimony and the shavings of hartshorn, until the sulphur is expelled and the organic matter dissipated, consists of this acid mingled with phosphate of lime.*

Properties of antimonic acid. A yellow powder, which when heated, parts with oxygen and is converted into antimonious acid.

Properties of protoxide of uranium. A dark green powder. Infusible. Found in the mineral kingdom.

Properties of sesquioxide of uranium. An orange yellow powder, known as uran-ochre in the mineral kingdom.

Properties of protoxide of cerium. A white powder, which when heated absorbs oxygen, and becomes sesquioxide of cerium.

Properties of sesquioxide of cerium. A fawn-red colored powder.

Properties of protoxide of bismuth. A yellow powder. Sp. gr. = 8.21. Fuses at a red, and sublimes at a more intense, heat.

Properties of the protoxide of titanium. A black powder; supposed to constitute the rare ore of titanium, called anatase.

Properties of titanitic acid. Color white; insoluble in water, and difficult to fuse. Exists crystallized in the mineral, called rutile; primary form, right square prism. Brittle, hard. Sp. gr. = 4.24. Color reddish brown, sometimes translucent.

Properties of tellurous acid. A white, granular powder, insoluble in water, and acid.

* It sometimes contains traces of the sesquioxide of antimony, to which its dia-phoretic property (as well as that of James' powder) has been ascribed.

Properties of telluric acid. Color lemon-yellow. At a strong heat, loses oxygen and becomes tellurous acid.

Properties of dioxide of copper. Color approaches copper-red. Sp. gr.=6.09. At a red heat, absorbs oxygen and is converted into the protoxide of copper. It occurs also in considerable quantity in the mineral kingdom, and is known as red copper-ore. Primary form, the cube.

Properties of protoxide of copper. The copper-black, or malacnite of mineralogists. Color dark brown to black. Sp. gr.=6.40. Insoluble in water.

Properties of dinoxide of lead. A dark grey, nearly black powder.

Properties of protoxide of lead (litharge or massicot). A lemon-yellow powder, which fuses, but remains fixed in the fire. Sp. gr. 9.42.

Properties of binoxide of lead. A brown powder. Red lead (minium), a mixture of protoxide and binoxide of lead.

Process of cupellation.

Table of oxygen-compounds with metals, the oxides of which are reduced to the metallic state by a red heat.

Protoxide of mercury,	202.	mercu.	+	8 oxy.	=210.	Hg+O
Binoxide	"	202.	"	+16 "	=218.	Hg+2O
Protoxide of silver,	108.	silver	+	8 "	=116.	Ag+O
Protoxide of gold,	199.2	gold	+	8 "	=207.2	Au+O
Binoxide	"	199.2	"	+16 "	=215.2	Au+2O
Teroxide	"	199.2	"	+24 "	=223.2	Au+3O
Protoxide of platinum,	98.8	plat.	+	8 "	=106.8	Pt+O
Binoxide	"	98.8	"	+16 "	=114.8	Pt+2O
Protoxide of palladium,	53.3	pal.	+	8 "	= 61.3	Pd+O
Binoxide	"	53.3	"	+16 "	= 69.3	Pd+2O
Protoxide of rhodium,	52.2	rhod.	+	8 "	= 60.2	R+O
Sesquioxide	"	104.4	"	+24 "	=128.4	2R+3O
Protoxide of osmium,	99.7	os.	+	8 "	=107.7	Os+O
Sesquioxide	"	199.4	"	+24 "	=223.4	2Os+3O
Binoxide	"	99.7	"	+16 "	=115.7	Os+2O
Teroxide	"	99.7	"	+24 "	=123.7	Os+3O

Properties of protoxide of mercury. A black powder, which is strongly prone to decomposition, into the binoxide and metallic mercury. Insoluble in water, and having a coppery taste.*

Properties of binoxide of mercury. Formed by slowly volatilizing mercury at 600° in a glass vessel with a broad bottom and a long neck, or by heating the nitrate of the protoxide of mercury until its nitric acid has suffered decomposition.† It is in the form of shining, crystalline scales of a blackish color while hot, but red when cold. Slightly soluble in water, has an acrid and metallic taste. When heated to redness, it is converted into oxygen and metallic mercury.

Properties of protoxide of silver. A brown powder, insoluble in water.

Properties of protoxide of gold. A green precipitate (from the action of potassa on a solution of protochloride of gold), which soon suffers decomposition into metallic gold and teroxide of gold.

Properties of the teroxide of gold. A yellowish, black powder, insoluble in water, and decomposed by solar light or a red heat.

Protoxide of platinum. A greenish powder.

Binoxide of platinum. A blackish, brown powder.

Sesquioxide of rhodium. A grey powder.

Protoxide of palladium. A black powder.

Binoxide of palladium. A yellowish, brown powder.

Compound of chlorine and nitrogen.

Quadrochloride of nitrogen. $141.68 \text{ chlorine} + 14.15 \text{ nitrogen} = 155.83 \text{ N} + 4\text{Cl}$. A yellow, oily fluid. Sp. gr. = 1.65 . It may be distilled at 160° , but at 200° it explodes with violence; also when in contact with certain combustible substances, as phosphorus and the oils.

Compound of chlorine and hydrogen.

Hydrochloric acid, $35.42 \text{ chlorine} + 1 \text{ hydrogen} = 36.42 \text{ H} + \text{Cl}$.

Properties of hydrochloric acid (muriatic acid). Formed by mingling equal measures of chlorine and hydrogen, and submit-

* Combined with saccharine matter, it forms the blue pill, and with lard, the blue or mercurial ointments. When camphor and ammonia are added to this last, the liniment of mercury is produced. The protoxide of mercury forms the active ingredient of the preparations of mercury, with and without chalk.

† When made by the first process it is called red precipitate *per se*.

ting the mixture to the action of sunlight, electricity or flame: a sudden inflammation ensues, attended by explosion. The product is a colorless gas, of a pungent odor and an acrid taste. Sp. gr.=1.2694, which is the mean of the two ingredients. It is irrespirable, does not burn, and extinguishes burning bodies. It has a strong attraction for water, condensing it in the form of a white cloud from the air, and instantly liquefying ice, when confined with it over mercury. Water at 40° absorbs 480 times its volume.

Table exhibiting the sp. gr. of H+Cl of determinate strengths.

Sp. gr.	Real acid in 100 of the liquid.			
1.203	-	-	-	40.65
1.179	-	-	-	37.00
1.162	-	-	-	33.94
1.149	-	-	-	31.34
1.139	-	-	-	29.13
1.128	-	-	-	27.20
1.119	-	-	-	25.51
1.112	-	-	-	24.02
1.106	-	-	-	22.70
1.100	-	-	-	21.51
1.096	-	-	-	20.44

Hydrochloric acid is decomposed by substances which yield oxygen readily: hence, when mingled with the binoxide of manganese, chlorine gas is plentifully afforded. A mixture of nitric and hydrochloric acids, in the ratio of one measure of the former to two of the latter, results in the decomposition of both acids, and the production of a solution, known as aqua regia.

Compounds of chlorine with several combustibles.

Sesquichlo. of phos.	106.26	chlo.	+31.4	phos.	=137.66	2P+3Cl
Perchloride	177.1	"	+31.4	"	=208.5	2P+5Cl
Protochlo. of carb.	35.42	"	+6.12	carb.	=41.54	C+Cl
Dichloride,	35.42	"	+12.24	"	=47.66	2C+Cl
Protochloride	106.26	"	+12.24	"	=118.5	2C+3Cl
Dichlo. of sulphur,	35.42	"	+32.	sulp.	=67.62	2S+Cl
Protochloride	35.42	"	+16.	"	=51.92	S+Cl
Terchlo. of boron,	106.26	"	+10.9	boron	=117.16	B+3Cl
" silicon,	106.26	"	+22.5	silicon	=128.76	Si+3Cl

Combination of chlorine with the metals. Phenomena attending the union.

Chlo. of potassium,	39.15 po. +	35.42 chlo. =	74.57	K + Cl
“ sodium,	23.3 sod. +	35.42 “ =	58.72	Na + Cl
“ lithium,	6.44 lit. +	35.42 “ =	41.86	Li + Cl
“ barium,	68.7 bar. +	35.42 “ =	104.12	Ba + Cl
“ strontium,	43.7 stro. +	35.42 “ =	79.22	Sr + Cl
“ calcium,	20.5 cal. +	35.42 “ =	55.92	Ca + Cl
“ magnesium,	12.7 mag. +	35.42 “ =	48.12	Mg + Cl
Sesquichlo. alumin.	27.4 alu. +	106.26 “ =	133.66	2Al + 3Cl
Protochlo. of manga.	27.7 ma. +	35.42 “ =	63.12	Mn + Cl
Perchloride “	55.4 “ +	247.94 “ =	303.34	2Mn + 7Cl
Protochloride of iron,	28. iron +	35.42 “ =	63.42	Fe + Cl
Sesquichlo. of iron,	56. “ +	106.26 “ =	162.26	2Fe + 3Cl
Chloride of zinc,	32.3 zinc +	35.42 “ =	67.72	Zn + Cl
“ cadmium,	55.8 cad. +	35.42 “ =	91.22	Cd + Cl
Protochloride of tin,	58.9 tin +	35.42 “ =	94.32	Sn + Cl
Bichloride of tin,	58.9 “ +	70.84 “ =	124.74	Sn + 2Cl
Chloride of cobalt,	29.5 cob. +	35.42 “ =	64.92	Co + Cl
Chloride of nickel,	29.5 nic. +	35.42 “ =	64.92	Ni + Cl
Protochlo. of arsenic,	37.7 ars. +	35.42 “ =	73.12	As + Cl
Sesquichloride “	75.4 “ +	106.26 “ =	181.66	2As + 3Cl
“ chromium,	56.2 chr. +	106.26 “ =	162.26	2Cr + 3Cl
Bichlo. of vanadium,	68.5 van. +	70.84 “ =	139.34	V + 2Cl
Terchloride “	68.5 “ +	106.26 “ =	174.76	V + 3Cl
Protochlo. of molyb.	47.7 mol. +	35.42 “ =	83.12	Mo + Cl
Bichloride “	47.7 “ +	70.84 “ =	118.54	Mo + 2Cl
Bichlo. of tungsten,	94.8 tung. +	70.84 “ =	165.64	W + 2Cl
Terchlo. of columb.	185. col. +	106.76 “ =	291.26	Te + 3Cl
Sesquichlo. of anti.	129.2 anti. +	106.26 “ =	235.46	2Sb + 3Cl
Bichloride “	64.6 “ +	70.84 “ =	135.44	Sb + 2Cl
Perchloride “	129.2 “ +	177.1 “ =	306.3	2Sb + 5Cl
Protochlo. of uran.,	217. ura. +	35.42 “ =	252.42	U + Cl
Sesquichloride “	434. “ +	106.26 “ =	540.26	2U + 3Cl
Protochl. of cerium,	46. cer. +	35.42 “ =	81.42	Ce + Cl
Sesquichloride “	92. “ +	106.26 “ =	198.26	2Ce + 3Cl
Chloride of bismuth,	71. bis. +	35.42 “ =	106.42	Bi + Cl
Bichlo. of titanium,	24.3 tita. +	70.84 “ =	95.14	Ti + 2Cl

Protochl. of tellurium,	64.2 tell.	+ 35.42 chlo.	= 99.62	Te + Cl
Bichloride	" 64.2 "	+ 70.84 "	= 135.04	Te + 2Cl
Dichloride of copper,	63.2 cop.	+ 35.42 "	= 98.62	2Cu + Cl
Protochloride	" 31.6 "	+ 35.42 "	= 67.02	Cu + Cl
Chloride of lead,	103.6 lead	+ 35.42 "	= 139.02	Pb + Cl
Protochl. of merc'ry,	202.2 mer.	+ 35.42 "	= 237.42	Hg + Cl
Bichloride	" 202. "	+ 70.84 "	= 272.84	Hg + 2Cl
Chloride of silver,	108. silv.	+ 35.42 "	= 143.42	Ag + Cl
Protochlo. of gold,	199.2 gold	+ 35.42 "	= 234.62	Au + Cl
Terechloride	" 199.2 "	+ 106.26 "	= 305.46	Au + 3Cl
Protochl. of platinum,	98.8 plat.	+ 35.42 "	= 134.22	Pt + Cl
Bichloride	" 98.8 "	+ 70.84 "	= 169.64	Pt + 2Cl
Protochl. of palladium,	53.3 pal.	+ 35.42 "	= 88.72	Pd + Cl
Bichloride	" 53.3 "	+ 70.84 "	= 124.14	Pd + 2Cl
Protochl. of rhodium,	52.2 rho.	+ 35.42 "	= 87.62	R + Cl
Sesquichloride	" 104.4 "	+ 106.26 "	= 210.66	2R + 3Cl
Protochl. of osmium,	99.7 osm.	+ 35.42 "	= 135.12	Os + Cl
Sesquichloride	" 199.4 "	+ 106.16 "	= 305.66	2Os + 3Cl
Bichloride	" 99.7 "	+ 70.84 "	= 170.54	Os + 2Cl
Terechloride	" 99.7 "	+ 106.26 "	= 205.96	Os + 3Cl

Properties of some of the most important chlorides.

Chloride of potassium. Anhydrous cubic crystals. Taste, saline and bitter. Soluble in 3 of water.

Chloride of sodium (common salt). Anhydrous cubic crystals. Fuses at a red heat. Soluble in 2 of water. Found abundantly in nature. Sources of common salt.

Chloride of lithium. Cubic crystals. Anhydrous, but very deliquescent. Alcoholic solution burns with a red flame.

Chloride of barium. Soluble in water, from which it crystallizes in flat tabular prisms, containing 2 equivalents of water. They dissolve in about twice their weight of water.

Chloride of strontium. Deliquesces in a moist atmosphere, and dissolves in 2 parts of water, from which prismatic crystals may be obtained, containing 9 equivalents of water. The alcoholic solution burns with a crimson flame.

Chloride of calcium. Crystallizes in prismatic crystals, which contain 6 equivalents of water. Very deliquescent. By heat it

loses its water; it fuses at a low red heat. On account of its attraction for water it is used for drying gases, and for frigorific mixtures with snow. Chloride of calcium, abundant in nature.

Chloride of magnesium. Highly deliquescent, and very soluble in water.

Protochloride of manganese. A pink-colored, crystalline substance, which is very deliquescent.

Perchloride of manganese. A greenish colored vapor.

Protochloride of iron. A white, crystalline substance, which forms with water a pale green solution. In standing some time, it absorbs oxygen from the air, and becomes yellow from the formation of sesquichloride of iron.

Sesquichloride of iron. In small iridescent plates of a red color: volatile at a heat a little above 212° . Deliquescent and readily soluble in water or alcohol.

Chloride of zinc (butter of zinc). A soft, lard-like substance: sublimes at a red heat, and deliquescent in the air.

Protochloride of tin. In transparent, prismatic crystals, which contain three equivalents of water.

Bichloride of tin (fuming liquor of Libavius). A volatile, colorless liquid, which boils at 248° , and with one third its weight of water, forms a solid hydrate. In the arts, it is commonly called permuriate of tin.

Chloride of cobalt. Pink colored crystals, which contain water. Very soluble in water, affording a pink colored solution. Forms a sympathetic ink.

Chloride of nickel. With water, forms an emerald-green solution. On being evaporated to dryness, it is yellow. It sublimes at a low red heat, and condenses in brilliant scales of a gold-yellow color.

Sesquichloride of arsenic. A colorless, volatile liquid, which fumes strongly when exposed to the air, and hence called the fuming liquor of arsenic.

Sesquichloride of antimony. At common temperatures, a soft solid, thence called butter of antimony. It is liquefied by a gentle heat, and crystallizes on cooling.

Chloride of bismuth. A greyish white, granular substance, which fuses at a low temperature. It has been called the butter of bismuth.

Dichloride of copper. It has the form of crystalline grains, and presents various colors according to its mode of preparation. It absorbs oxygen from the air, forming a green colored compound of protoxide, and protochloride, of copper. In this condition, it appears to occur in the mineral kingdom, forming the mineral called atacamite.

Chloride of lead. In small acicular crystals: fuses below redness, and forms a semi-transparent mass, whose sp. gr. = 5.13. It is called horn-lead; and is known to a small extent in the mineral kingdom, under the name of corneous lead.

Protochloride of mercury (calomel). It is a rare mineral, known to mineralogists under the name of horn-quicksilver. Crystallizes in the form of the right square prism. Color greyish-white. Sectile. Sp. gr. = 6.48. As obtained for pharmaceutic purposes, it is in semi-transparent, crystalline cakes, or in the condition of a white powder; and has the specific gravity of 7.2. At a heat a little below redness, it rises in vapor without previous fusion; but during the sublimation, a portion is always resolved into mercury, and the bichloride of mercury. It is tasteless, and insoluble in water.

Bichloride of mercury (corrosive sublimate). When obtained by sublimation, it is in semi-transparent, colorless masses, possessed of a crystalline texture. Sp. gr. = 5.2. At a heat considerably below redness, it is fused, and rises into vapor, which concretes on cold surfaces in white, crystalline coatings. It dissolves in 20 times its weight of water at 60°, and in twice its weight at 212°. It has an acrid, metallic taste; and is a virulent poison. Method of detecting corrosive sublimate. Process of Kyanising wood.

Chloride of silver. The horn-silver of mineralogists. Crystallizes in the form of the cube. Sectile. Color pearl-grey. Sp. gr. = 5.5. As formed by precipitation, it is white; but by a short exposure to the solar rays, it first passes to violet and thence to black. Insoluble in water, but soluble in ammonia. It fuses at 500°, and forms on cooling, a horny, semi-transparent mass.

Chlorides of gold. The solution of terchloride of gold on being evaporated, affords ruby-red, prismatic crystals, which deliquesce on being exposed to the air. At 400°, it begins to lose chlorine and is changed into a brown mass, which is a mixture of

the protochloride and terchloride. At 600° , it is resolved into the yellow, insoluble protochloride, which by boiling in water, is changed into metallic gold and the soluble terchloride.

Chlorides of platinum. The red, hydrated bichloride of platinum is very deliquescent and soluble in water, alcohol and ether. When heated to 450° , half its chlorine is expelled, and the protochloride remains of a greenish gray color.

Chlorides of oxides.

Chloride of soda. Use as a disinfecting agent.

Chloride of lime. Use as a bleaching agent.

Compound of bromine and hydrogen.

Hydrobromic acid, 78.4 brom. + 1 hydrogen = 79.4 H + Br.

Properties of hydrobromic acid. A colorless gas, having an acid taste and pungent odor. Irrespirable, exciting the glottis powerfully, even when mingled largely with common air. Strong attraction for water, condensing it from the air in the form of dense, white vapors. Its sp. gr. = 2.73. Very soluble in water. Chlorine decomposes the solution instantly. Nitric acid acts upon it, as it does upon hydrochloric acid,—forming a liquid analogous to aqua-regia.

Compounds of bromine with several combustibles.

Protobromide of phos., 78.4 brom. + 15.7 phos. = 94.1 P + Br.

Perbromide of “ 392. “ + 31.4 “ 423.4 2P + 5Br.

Bromide of carbon, composition undetermined.

Terbromide of silicon, 235.2 brom. + 22.5 silic. = 257.7 Si + 3Br.

Table of some of the most important metallic bromides.

Brom. of potas.	^{Symbols.} K + Br	{ Anhydrous cubic crystals; very soluble in water.
“ sod.	Na + Br	{ Anhydrous cubic crystals; found in seawater and salines. Method of testing for bromine.
“ mag.	Mg + Br.	In acicular crystals, deliquescent.
“ lead,	Pb + Br.	A white crystalline powder.
Protobrom. of mercury.	{ Hg + Br.	A white insoluble powder.
Bibromide of mercury.	{ Hg + 2Br.	A white crystallizable compound, soluble in water and alcohol, and analogous to the Hg + 2Cl.

Compound of iodine and nitrogen.

Teriodide of nitrogen. Iodine 378·9 + nitrogen 14·15 = 393·05.

$N + 3I$.

Properties of $N + 3I$. A blackish powder, which detonates violently as soon as it is dry, being converted into its elements.

Compound of iodine and hydrogen.

Hydriodic acid. Iodine 126·3 + hydrogen 1 = 127·3 $H + I$.

Properties of $H + I$. An acid gas, which on account of its attraction for water, produces dense, white fumes in the air. Sp. gr. = 4·38. Its strongest aqueous solution has a sp. gr. = 1·7. The solution is decomposed on exposure of a few hours to the atmosphere; the oxygen of the air forming water with the hydrogen of the acid, and the iodine being set free.

Compounds of iodine and phosphorus.

Protiodide of phosphorus, iod. 126·3 + phos. 14·15 = 142· $P + I$

Sesquiodide " " 378·9 + " 31·4 = 410·3 $2P + 3I$

Periodide " " 631·5 + " 31·4 = 662·9 $2P + 5I$

Properties of the iodides of phosphorus. They are decomposed by water, with the elements of which, they give rise to hydriodic and phosphorous acids.

Compounds of iodine and carbon.

" " sulphur.

Iodides of the metals.

Iodide of potassium. Pot. 39·15 + iod. 126·3 = 165·45 $K + I$

" sodium. Sod. 23·3 + " 126·3 = 149·6 $Na + I$

Protiodide of iron. Iron. 28· + " 126·3 = 154·3 $Fe + I$

Sesquiodide " " 56· + " 378·9 = 434·9 $2Fe + 3I$

Periodide of arsenic. Arse. 75·4 + " 631·5 = 706·9 $2As + 5I$

Iodide of lead. Lead, 103·6 + " 126·3 = 229·9 $Pb + I$

Protiod. of mercury. Mer. 202· + " 126·3 = 328·3 $Hg + I$

Sesquiodide " " 404· + " 378·9 = 782·9 $2Hg + 3I$

Biniodide " " 202· + " 252·6 = 454·6 $Hg + 2I$

Iodide of silver. Silv. 108· + " 126·3 = 234·3 $Ag + I$

Protiodide of gold. Gold, 199·2 + " 126·3 = 325·5 $Au + I$

Teriodide " " 199·2 + " 378·9 = 578·1 $Au + 3I$

Protiod. of platinum. Plat. 98·8 + " 126·3 = 225·1 $Pt + I$

Biniodide " " 98·8 + " 252·6 = 351·4 $Pt + 2I$

Properties of iodide of potassium (hydriodate of potassa). Readily formed by adding iodine to a hot solution of pure potassa until the alkali is neutralized: iodide of potassium and iodate of potassa are formed. The solution is evaporated to dryness, and exposed in a platinum crucible to a gentle red heat. It is very soluble in water, and deliquesces in a moist atmosphere. By evaporating the solution, it affords cubic crystals of the iodide. The commercial iodide contains numerous saline impurities. The iodide of potassium is found in sea-water, marine plants and animals, and in certain mineral springs and salines. Mode of testing for iodine.

Properties of iodide of sodium (hydriodate of soda). Formed in a manner similar to the iodide of potassium, which it resembles in many of its properties. It is found in nature along with the iodide of potassium.

Properties of iodide of iron. An iron-grey colored substance. It is deliquescent, and very soluble in water and alcohol. Its aqueous solution attracts oxygen rapidly from the air, and undergoes the same kind of change as the protochloride. To preserve a solution of protiodide of iron, it should contain fragments of fine iron wire.

Periodide of arsenic. Formed by boiling 37·7 parts pulverized arsenic and 126 of iodine, and evaporating the filtered solution to dryness. Color garnet-red. Soluble in water. An active poison; used in doses of one tenth of a grain, in cases of obstinate lepra.

Iodide of lead. In rich yellow, crystalline scales, having a brilliant lustre. When taken internally, the dose should not exceed one fourth of a grain. An ointment is made from one drachm of the iodide, to one oz. of lard.

Protiodide of mercury. A green powder, insoluble in water.

Sesquiodide “ A yellow powder.

Biniodide “ A vermilion-red powder.

The dose of these iodides at first, is from one fourth, to one sixth of a grain: for external application, half a drachm of the iodide, to one oz. of lard.

Iodide of silver. A greenish yellow powder, when artificially formed; but iodic silver, as it occurs in the mineral kingdom, is in greyish white semi-metallic plates, which are soft, flexible, and translucent.

Compound of fluorine and hydrogen.

Hydrofluoric acid. Fluorine $18.68 + \text{hyd. 1} = 19.68 \text{ H} + \text{F}$.

Properties of $\text{H} + \text{F}$. Between 32° and 59° a colorless liquid. Sp. gr. = 1.06. Exposed to the air, it rapidly flies off, in dense white fumes. Its affinity for water is very great. Of all known substances, it is the most destructive to organized matter. The vapor of hydrofluoric acid is the most irritating of all gases. When brought in contact with glass or any other siliceous compound, it suffers decomposition, in common with the vitreous substance, which becomes eroded. It is hence used for etching on glass.

Compound of fluorine and boron.

Terfluoride of boron. Fluorine $56.04 + \text{boron } 10.9 = 66.94 \text{ B} + 3\text{F}$

Properties of $\text{B} + 3\text{F}$ (fluoboric acid). A colorless gas, having a pungent odor. Extinguishes burning bodies. Sp. gr. = 2.36. Water absorbs 700 volumes of this gas. In a certain state of dilution, the $\text{B} + 3\text{F}$ and water decompose each other, giving rise to $\text{H} + \text{F}$ and boric acid.

Compound of fluorine and silicon.

Terfluoride of silicon. Fluorine $56.04 + \text{sil. } 22.5 = 78.54 \text{ Si} + 3\text{F}$

Properties of $\text{Si} + 3\text{F}$ (fluosilicic acid). A colorless gas, which does not support flame or animal life; it powerfully irritates the respiratory organs. Sp. gr. = 3.61. It suffers decomposition, when brought in contact with water,—silicon and hydrofluoric acids being produced; the liquid contains the whole of the $\text{H} + \text{F}$, and two thirds of the silicic acid, while the remaining one third is deposited in a gelatinous form.

Fluorides of metals.

Symbol.

Fluoride of potassium. $\text{K} + \text{F}$. Deliquescent white cubic crystals.

Fluoride of calcium (fluat of lime). $\text{Ca} + \text{F}$. A well known and abundant mineral, called fluor, or fluor spar. Primary form, the cube. Lustre, vitreous. Colors, various. Brittle. Sp. gr. = 3.140. Phosphorescent by heat.

Fluoride of manganese. $2\text{Mn} + 7\text{F}$. A yellow gas.

Fluoride of cerium. Found in the mineral kingdom, and called fluorine.

Cyanogen compounds.—Cyanogen, although a compound ($N+2C$), sustains relations to the elements, strongly analogous to the supporters of combustion. The compounds it aids to form will now be described, in the order adopted above in regard to supporters.

Compound of cyanogen and oxygen.

Cyanic acid.* Cyanogen $26\cdot39 + \text{oxygen } 8 = 34\cdot39$ $N+2C+O$.

Properties of cyanic acid. A weak acid, having the smell of vinegar. When left in contact with water for a few hours, it suffers decomposition and gives rise to carbonate of ammonia.

Chloride of cyanogen.

Bromide of cyanogen.

Iodide of cyanogen.

Disulphuret of cyanogen.

Sulphuret of cyanogen.

Bisulphuret of cyanogen.

Seleniet of cyanogen.

Compound of cyanogen and hydrogen.

Hydrocyanic acid. Cyanogen $26\cdot39 + \text{hydrogen } 1 = 27\cdot39$. $N+2C+H$.

Properties of hydrocyanic acid (prussic acid). A colorless liquid, with the odor of peach-blossoms. At $44\frac{1}{2}^{\circ}$ its sp. gr. = $0\cdot7$. At $64\frac{1}{2}^{\circ}$ its sp. gr. = $0\cdot69$. It boils at 79° and congeals at 5° . At 80° , it is a gas, having a sp. gr. equal to the mean of equal volumes of cyanogen and hydrogen gases, i. e. = $0\cdot94$. This acid is a virulent poison. It undergoes spontaneous decomposition in a short time: but when diluted with water, it may be preserved for any length of time, provided the access of light be prevented. Ammonia and chlorine are the antidotes to this acid. Method of detecting it when fatally administered.—Different processes for obtaining the acid for medicinal uses.—Its existence in plants.

Compounds of cyanogen and the metals.

Cyanide of potassium. Potassium $39\cdot15 + \text{cyanogen } 26\cdot39$. A white saline body, having a bitter and alkaline taste: readily solu-

* Fulminic acid, though possessed of different properties from cyanic acid, is still believed to be identical with it, in composition.

ble in water and alcohol. It possesses the same sedative properties with prussic acid, and not being liable to spontaneous decomposition, might, with advantage, be substituted for that therapeutic agent.

Bicyanide of mercury. In small prismatic crystals, of a white color. It is readily soluble in water and weak alcohol. The solution has a bitter, metallic taste. When heated, it blackens, and gives out cyanogen and metallic mercury.

Sulphocyanogen compounds.—The bisulphuret of cyanogen, like cyanogen itself, plays the part of a radical, forming with hydrogen the

Hydrosulphocyanic acid. It has an exceedingly sour taste, and an odor like acetic acid. It boils at 216° , and crystallizes at 40° . When treated with the metallic oxides, like other hydracids, mutual decomposition ensues, water and sulphocyanides of the metals are formed.

The sesquisulphocyanide of iron has a deep blood-red color.

Ferrocyanogen compounds.—This radical has not been obtained in an insulated form.

Hydroferrocyanic acid. A fluid having a pale lemon-yellow color. It is decomposed by a gentle heat, or by exposure to light. With metallic oxides, decomposition follows, and water and ferrocyanides are formed.

Ferrocyanide of potassium (prussiate of potash or ferroprussiate of potash). According to **BERZELIUS**, it consists of two equivalents of potassium + one of iron + three of cyanogen + three of water. The manner in which these constituents are arranged will be better understood, after the consideration of the higher compounds of the salts. Suffice it here to state, that what is called the ferrocyanide of potassium, is regarded as a double cyanide, consisting of two equivalents of cyanide of potassium + one of cyanide of iron, combined with three proportionals of water in the crystallized compound. It is formed by burning the hoofs of cattle, mixed with nitre in iron pots, lixiviating what remains after this process, and setting the liquid aside when sufficiently concentrated. Large tabular crystals are produced, of a pure yellow color and transparent. Sp. gr. = 1.83. Taste, saline, cool and disagreeable. Water at 54° dissolves nearly one quarter

its weight of the salt. When moderately heated, it gives up its water of crystallization without being otherwise altered.

Ferrocyanides of other metals are readily formed when their oxides or chlorides in solution, are treated with a solution of ferrocyanide of potassium,—the oxygen or chlorine in such cases leaving the metals to unite with the potassium, while the ferrocyanogen passes to the metal. And as these ferrocyanides are generally insoluble and afford a variety of colors, the chemist often employs a solution of ferrocyanide of potassium, as a test to ascertain the nature of unknown metals in solutions.

Metallic solutions.			Colors of precipitates.
Antimony,	-	-	white:
Bismuth,	-	-	white.
Cadmium,	-	-	white, a little yellowish.
Cerium (protoxide),	-	-	white, soluble in acids.
Cobalt,	-	-	green, soon turning reddish grey.
Copper (protoxide),	-	-	white, changing to red.
Do. (peroxide),	-	-	reddish brown.
Iron (protoxide),	-	-	white, rapidly turning blue.
Do. (peroxide),	-	-	dark blue.
Lead,	-	-	white, with a yellowish cast.
Manganese (protoxide),	-	-	white, turning peach or blood-red.
Do. (deutoxide),	-	-	greenish grey.
Mercury (protoxide),	-	-	white.
Do. (peroxide),	-	-	white, turning blue.
Molybdenum,	-	-	dark brown.
Nickel (oxide),	-	-	white, turning greenish.
Palladium (protoxide),	-	-	green (gelatinous).
Silver,	-	-	white, turning brown with light.
Columbium,	-	-	yellow, dark burnt color.
Tin (protoxide),	-	-	white (gelatinous).
Do. (peroxide),	-	-	white (gelatinous).
Uranium,	-	-	red-brown.
Zinc,	-	-	white.

Prussian blue.—Formed by mingling solutions of ferrocyanide of potassium and copperas. A light blue precipitate falls, which is washed several times a day with cold water for several weeks. The color gradually deepens, until at length it possesses an in-

tensely rich hue, connected with a sub-metallic lustre. It is insoluble in water, alcohol, ether, oils and dilute acids. It has, according to **BERZELIUS**, the following constitution : one equivalent of iron, one of cyanogen, and one and a half of water.

SECONDARY COMPOUNDS.

Division of primary compounds into acids, bases and neutrals. All the most important bi-elementary compounds have now been described ; the next step will be, to inquire concerning the higher compounds these bodies are capable of forming by inter-combination, after the manner of elements themselves. A part of the primary compounds described are incapable, so far as we now know, of combining again ; these are called neutrals. Acids and bases on the other hand, unite readily the one with the other, giving rise to a class of compounds, called salts. By an acid is meant a substance (whether sour, sweet or tasteless), which combines with bases, i. e. which unites with them in fixed proportions,—the union being attended with the usual disguise of properties in chemical combinations. The bases have sometimes been called alkalies,—several of those which were first known to mankind having strong alkaline properties ; but the term base has been extended like that of acid to embrace a large group, which though well marked on the whole, it is yet difficult to define. They may however, be said to be, compounds of the metals (with the exception of the base ammonia), with the supporters of combustion (and with certain vicarious supporters), which if sapid are not sour, which are indisposed to mutual combination, but are free to unite with acids. The number of neutrals among the metallic oxides is small ; among the chlorides, iodides, bromides, fluorides, cyanides, &c., however, the proportion is very great : while the number is still greater among the phosphurets, sulphurets, &c. ; but no base or acid whatever, is known among the carburets, borets, silicets, or among the compounds between the unmetallic combustibles and the supporters of combustion.

Acids form several independent groups, characterized by the supporter of combustion, or vicario-supporter, they contain : thus we have oxygen-acids, chlorine-acids, bromine-acids, sulphur and selenium-acids, &c.

Bases form corresponding groups, and hence there are oxygen-bases (oxides), chlorine-bases (chlorides), sulphur-bases, &c., and in addition, the alkaline compound of nitrogen and hydrogen, ammonia.

When an acid and base unite to form a salt (unless the base be ammonia), the same supporter or vicario-supporter exists in the acid, as in the base.

Nomenclature of salts.

OXYGEN-ACID SALTS.

Carbonates. They are decomposed with effervescence by nearly all the acids; and all of them, excepting the carbonates of potassa, soda and lithia may be deprived of their acid by heat. They are but little soluble in water, with the exception of the alkaline carbonates.

Table of simple carbonates.

	Base.	Acid.	Equiv.	Symbol.
Carb. of potassa,	47·15	1 eq. + 22·12	1 eq. = 69·27	KO + CO ²
Bicarb. " "	47·15	1 " + 44·24	2 " = 91·39	KO + 2CO ²
" in crystals with 9 or 1 eq. of water,				= 100·39
Carb. of soda,	31·3	1 eq. + 22·12	1 eq. = 53·42	NaO + CO ²
" in crystals, with 90 or 10 eq. of water				= 143·42
" " " 63 or 7 " "				= 116·42
Bicarb. of soda,	31·3	1 eq. + 44·24	2 eq. = 75·54	NaO + 2CO ²
" in crystals with 9 or 1 eq. of water				= 85·54
Carb. ammonia,	17·15	1 eq. + 22·12	1 eq. = 39·27	H ³ N + CO ²
Bicarb. " "	17·15	1 " + 44·24	2 " = 61·39	H ³ N + 2CO ²
Carb. baryta,	76·7	1 " + 22·12	1 " = 98·82	BaO + CO ²
" strontita,	51·8	1 " + 22·12	1 " = 73·92	SrO + CO ²
" lime,	28·5	1 " + 22·12	1 " = 50·62	CaO + CO ²
" magnesia,	20·7	1 " + 22·12	1 " = 42·82	MgO + CO ²
" in crystals with 27 of water or 3 "				
Carb. prot. iron,	36	1 eq. + 22·12	1 " = 58·12	FeO + CO ²
Dicarb. prot. cop.	79·2	2 " + 22·12	1 " = 101·32	2CuO + CO ²
" (in malachite) with 9 or 1 eq. of water				= 110·32
Carb. prot. lead,	111·6	1 eq. + 22·12	1 eq. = 133·72	
Dicarb. per. mer.	436	2 " + 22·12	1 " = 458·12	2HgO ² + CO ²

Table of double carbonates.

			Equiv.		Symbol.
Carb. of lime	} carb. lime,	50.62 1eq.	} = 93.44	{	MgO, CO ²
and magnesia.		" magnesia, 42.82 1 "			+ CaO, CO ²
Carb. baryta	} carb. baryta,	98.82 1 "	} = 149.44	{	CaO, CO ²
and lime.		" lime, 50.62 1 "			+ BaO, CO ²

Carbonate of potassa (pearlash, potash). Derived in an impure state, from lixiviating the ashes of wood. Methods for obtaining the salt pure.—It is slightly caustic, and has a strongly alkaline taste. Dissolves in less than its weight of water at 60°, deliquesces rapidly, and crystallizes with much difficulty from the solution. Insoluble in alcohol. Fuses at a full red heat.

Bicarbonate of potassa. Less caustic and alkaline than the carbonate. Does not deliquesce, and requires four times its weight of water at 60° for its solution. It is converted into a carbonate by a low red heat.

Carbonate of soda (sal-soda, barilla, kelp). Obtained by lixiviating the ashes of sea-plants. Primary form, a right rhombic prism. The crystals effloresce on exposure to the air: they are rendered anhydrous without loss of carbonic acid. Dissolves in two of cold water, the solution having a strong alkaline taste. It is found in the mineral kingdom, and known under the names of natron and trona.

Bicarbonate of soda. Deposited in hydrated, crystalline grains, on the evaporation of its solution. It requires 10 parts of water for its solution at 60°. It loses much of its carbonic acid by boiling; and at a red heat, is reduced to the state of carbonate.

Carbonate of ammonia. Formed by mingling one volume of dry carbonic acid, with two of ammoniacal gas. A light, white powder, which on the access of moisture is decomposed into water and sesquicarbonate of ammonia.

Sesquicarbonate of ammonia (subcarbonate of ammonia). Hard, compact, crystalline, white salt, and possesses a strong ammoniacal odor. When exposed to the air, it loses weight rapidly from the loss of ammonia, and leaves behind a porous, brittle mass, which is bicarbonate of ammonia.

Carbonate of baryta. Found in the mineral kingdom, and called Witherite. Primary form, a right rhombic prism of 118°. Sp.

gr.=4.3. Brittle. Color white. Anhydrous and insoluble. Poisonous.

Carbonate of strontita. The strontianite of the mineral kingdom. Crystal, a right rhombic prism of $117^{\circ} 32'$. Color greenish white. Sp. gr.=3.6. Brittle. Anhydrous and insoluble.

Carbonate of lime (calcite, limestone, chalk, calcareous spar, &c.) The most abundant carbonate, in nature. Primary form, a rhomboid of $105^{\circ} 5'$. Sp. gr.=2.72. Brittle. Anhydrous and insoluble in water, unless it contains carbonic acid. When calcined in furnaces, forms quick-lime.

Carbonate of magnesia. When artificially prepared (by adding carbonate of potassa in excess to a hot solution of sulphate of magnesia (epsom-salts) and well washing the precipitate), is a tasteless, white powder, requiring 2493 of cold, and 9000 of hot water for solution. It is known in the mineral kingdom, under the name of magnesite.

Carbonate of protoxide of iron. When prepared through the precipitation of a solution of sulphate of the protoxide of iron (copperas), by carbonate of soda, washing the precipitate by means of hot water, and speedily drying it between folds of blotting paper, it is of a reddish brown color. Insoluble in water, and tasteless. Found dissolved in mineral water, by means of carbonic acid. It likewise exists abundantly in the mineral kingdom, under the name of spathic iron. Primary form of crystal, a rhomboid of 107° . Color brown. Sp. gr.=3.82. Brittle. An abundant source of iron and steel.

Dicarbonate of protoxide of copper. Occurs in the mineral kingdom, forming the species, green and blue malachite. The blue pigment, called verditer, prepared by decomposing nitrate of copper with chalk, has a similar composition.

Carbonate of protoxide of lead (white lead, ceruse). As prepared for use in the arts, is a pulverulent, white substance, insoluble in water, and having a sp. gr.=6.72. Abundant in the mineral kingdom, and called white lead-ore. Primary form, a right rhombic prism of 117° .

Carbonate of lime and magnesia (dolomite, dolomitic limestone, marble, bitter-spar, and pearl-spar). Nearly as abundant in nature as the carbonate of lime, which it strongly resembles. Primary

form, a rhomboid of $106^{\circ} 15'$. Brittle, rather harder than carbonate of lime. Sp. gr.=2.88. It is frequently burnt for quicklime.

Carbonate of baryta and lime. The baryto-calcite of the mineral kingdom.

Sulphates. General properties of sulphates. A soluble sulphate is characterized by yielding a white precipitate (which is insoluble in acids or alkalies), on being treated with a solution of chloride of barium: an insoluble sulphate affords the same result with chloride of barium, if previously heated to redness, in fine powder, with three times its weight of carbonate of potassa or soda, the residue being dissolved in water, filtered and neutralized by pure nitric or hydrochloric acid.

The sulphates of baryta, of tin, antimony, bismuth, lead and mercury are insoluble; those of strontita, lime, zirconia, yttria, cerium and silver are sparingly soluble, while the others are freely soluble in water.

All the sulphates, excepting those of potassa, soda, lithia, baryta, strontita and lime, are decomposable at a white heat. One part of the sulphuric acid escapes unchanged during the calcination, while another is resolved into sulphurous acid and oxygen. When a sulphate mixed with carbonaceous matter is ignited, the oxygen both of the acid and the base unites with the carbon, carbonic acid is disengaged, and a metallic sulphuret remains.

Table of simple Sulphates.

	Base.	Acid.	Equiv.	Symbol.
Sulph. of pot.	47.15	1 eq. + 40.1	1 eq. =	87.25 KO + SO ³
Sesquisul. "	94.3	2 " + 120.3	3 " =	214.6 2KO + 3SO ³
Do. in crystals with 9, or 1 eq. of water	= 223.6.			
Bisul. of pot.	47.15	1 eq. + 80.2	2 eq. =	127.35 KO + 2SO ³
Do. with 9, or 1 equivalent of water.				
Sul. of soda,	31.3	1 eq. + 40.1	1 eq. =	71.4 NaO + SO ³
Do. in crystals with 90, or 10 eq. of water	= 161.4.			
Bisul. of soda,	31.3	1 eq. + 80.2	2 eq. =	111.5 NaO + 2SO ³
Do. in crystals with 36, or 4 eq. of water	= 147.5.			
Sul. of lithia,	14.44	1 eq. + 40.1	1 eq. =	54.54 LO + SO ³
Do. in crystals with 9, or 1 eq. of water	= 63.54.			
Sul. of am.	17.15	1 eq. + 40.1	1 eq. + 1 eq. wat.	H ³ N + SO ³ + HO

	Base.	Acid.	Equiv.	Symbol.
Sul. of baryta,	76·7 1 eq. +	40·1 1 eq. =	116·8	BaO + SO ³
“ strontita,	51·8 1 eq. +	40·1 1 eq. =	91·9	SrO + SO ³
“ lime,	28·5 1 eq. +	40·1 1 eq. =	68·6	CaO + SO ³
“ “ with 18, or 2 eq. of water =			86·6	
“ mag.	20·7 1 eq. + 40·1 1 eq. + 1 eq. of water			MgO + SO ³ HO
“ “ in crystals with 54, or 6 eq. of water =			123·8.	
“ alumina,	51·4 1 eq. + 40·1 1 eq. =		91·5	Al ² O ³ + SO ³
“ “ in crystals with 81, or 9 eq. of water =			172·5.	
Tersul. “	51·4 1 eq. + 120·3 3 eq. =		171·7	Al ² O ³ + 3SO ³
“ “ in crystals with 162, or 18 eq. of water =			333·7.	
Sul. prot. man.	35·7 1 eq. + 40·1 1 eq. + 1 eq. wat.			MnO + SO ³ HO
“ “ iron,	36· 1 eq. + 40·1 1 eq. + 1 “ “			FeO + SO ³ HO
“ “ in crystals with 45, or 5 eq. of water =			130·1.	
Tersul. ses. iron,	80· 1 eq. + 120·3 3 eq. =		200·3	Fe ³ O ³ + 3SO ³
Disul. “ “	160· 2 eq. + 40·1 1 eq. =		200·1	2Fe ² O ³ + SO ³
“ as an hydrate with 54, or 6 eq. of water =			254·1.	
Sul. prot. zinc,	40·3 1 eq. + 40·1 1 eq. + 1 eq. wat.			ZnO + SO ³ HO
“ in crystals with 54, or 6 eq. of water.				
Sul. prot. nick.	37·5 1 eq. + 40·1 1 eq. + 1 eq. wat.			NiO + SO ³ HO
“ in crystals with 54, or 6 eq. of water =			140·6.	
Sul. prot. cob.	37·5 1 eq. + 40·1 1 eq. + 1 eq. wat.			CoO + SO ³ HO
“ in crystals with 45, or 5 eq. of water =			131·6	
Tersul. ses. chrom.	80· 1 eq. + 120·3 3 eq. =		200·3	Cr ² O ³ + 3SO ³
Sul. prot. cop.	39·6 1 eq. + 40·1 1 eq. + 1 eq. wat.			CuO + SO ³ HO
“ in crystals with 36, or 4 eq. of water =			124·7.	
Disul. prot. cop.	79·2 2 eq. + 40·1 1 eq. =		119·3	2CuO + SO ³
Sul. prot. merc.	210· 1 eq. + 40·1 1 eq. =		250·1	HgO + SO ³
Subsul. per. “	872· 4 eq. + 120·3 3 eq. =		992·3	4HgO ² + 3SO ³
Bisul. “ “	218· 1 eq. + 80·2 2 eq. =		298·2	HgO ² + 2SO ³
Sul. of silver,	116· 1 eq. + 40·1 1 eq. =		156·1	AgO + SO ³

Table of double Sulphates.

Names.	Constituent Salts.	Equiv.	Symbol.
Sul. pot. and alum.	{ Sul. potassa, 87·25 1 eq. } { Tersul. alu. 171·7 1 eq. }	= 258·95	{ KO, SO ³ + Al ² O ³ + 3SO ³
Do.	with 216 or 24 eq. of water =	474·95.	
Sul. sod. and alum.	{ Sul. soda, 71·4 1 eq. } { Tersul. al. 171·7 1 eq. }	= 243·1	{ NaO, SO ³ + Al ² O ³ + 3SO ³
Do.	with 234 or 26 eq. of water.		

Sulphate of potassa. Primary form, right rhombic prism of $112^{\circ} 8'$. Soluble in 16 of water at 60° , and in 5 at 212° . Taste, saline and bitter. Found in nature, and called *aphthitalite*.

Bisulphate of potassa. Has a strongly sour taste. Soluble in twice its weight of water at 60° . It is resolved by heat, into sulphuric acid and sulphate of potassa.

Sulphate of soda (glauber's salt). Occurs in nature, both in the crystalline state, and dissolved in certain mineral waters. Primary form an oblique rhombic prism of $119^{\circ} 36'$, the usually occurring form being a six sided prism, surmounted by dihedral summits. The crystals on exposure to the air, soon part with their water of crystallization: when heated also, they readily undergo the watery fusion. At 32° , 100 parts of water dissolve 12 parts of the crystals, 48 parts at $64\frac{1}{2}^{\circ}$, 100 parts at 77° , 270 at $89\frac{1}{2}^{\circ}$, and 322 at $91\frac{1}{2}^{\circ}$. On increasing the heat beyond this point, a portion of the salt is deposited.

Sulphate of ammonia. The *mascagnine* of mineralogists. It is also found in coal-soot. It dissolves in two parts of water at 60° . In dry air, it effloresces, losing one equivalent of water.

Sulphate of baryta. An abundant sulphate in the mineral kingdom, and known as *heavy-spar*. Primary form, a right rhombic prism of $101^{\circ} 42'$. Sp. gr.=4.44. Brittle; hardness equal to that of carbonate of lime. Color, white. Lustre, vitreous.

Sulphate of strontita. The *celestine* of mineralogists. Primary crystal, right rhombic prism of 104° . Sp. gr.=3.85. Hardness, that of carbonate of lime. Color white, with a shade of blue. Lustre, vitreous.

Sulphate of lime. This salt with two equivalents of water is the *gypsum* of the mineral kingdom, and is the most abundant of all the sulphates in nature. Primary crystal, right oblique angled prism, M on T= $113^{\circ} 8'$. Sp. gr.=2.31. Soft, sectile. Color, various shades of white. Lustre, vitreous. It requires 500 of water at 60° , for the solution of one part of this salt. The taste is scarcely perceptible. It is often present in well-water. Gypsum is rendered anhydrous at 300° , when it is known in the arts as *plaster of Paris*. On being treated with its proper proportion of water, it solidifies, or returns to its original condition. Sulphate of lime is also found in the anhydrous state in the mineral kingdom, forming the mineralogical species, *anhydrite*.

Sulphate of magnesia (epsom-salt). Found in the mineral kingdom, and especially, dissolved in certain mineral waters. It crystallizes in quadrangular prisms, the primary form being a right rhombic prism of $90^{\circ} 30'$. Soluble in an equal weight of water at 60° . Dried at 212° , it retains two equivalents of water; at 270° , one of these is expelled, while it becomes anhydrous at 460° . Sources of epsom-salt to the arts.

Sulphates of alumina. The tersulphate is found in nature, and has been called solfatarite. It has an acid reaction. The hydrated sulphate is also a natural production, and known as Websterite. It is insoluble in water.

Sulphates of iron. The sulphate of the protoxide (copperas) is a frequent production of the mineral kingdom, and is largely manufactured for the arts, by the process of sulphatization. Primary form of the crystal, an oblique rhombic prism, M on $M = 82^{\circ} 20'$, P on $M = 99^{\circ} 20'$. Color, several shades of green. Brittle. Sp. gr. = 1.83. Soluble in two of cold water, and in three fourths its weight of boiling water. Taste, styptic. The crystals contain 6 equivalents of water. When thoroughly dried by the fire, it crumbles down to a white powder, with the loss of 5 equivalents of water. On exposing the dried salt to a red heat, its acid is wholly expelled in combination with the remaining equivalent of water. The acid thus obtained, constitutes the oily, brown fluid, called fuming sulphuric acid. It consists of two equivalents of real acid + one of water. Its sp. gr. = 1.89 to 1.9.

The tersulphate of the sesquioxide dissolves slowly in water, imparting to it an orange-yellow color. The disulphate of the sesquioxide falls as an hydrate of an ochre-yellow color, when a solution of the protosulphate is kept in an open vessel.

Sulphate of zinc (white vitriol). Found in small quantity in the mineral kingdom. Crystal, right rhombic prism of $90^{\circ} 42'$. Sp. gr. = 2.03. It dissolves in two and a half of cold water. Taste, acid and styptic.

Sulphates of copper. The sulphate of the protoxide, called blue vitriol, is found in nature, and largely manufactured for use in the arts. Primary form of the crystal, a doubly oblique prism. Sp. gr. = 2.20. Soluble in four parts of cold water. Taste,

astringent and metallic. The crystals give up 4 equivalents of water at 212° , and the fifth at 430° , when they become a white powder.

The disulphate is formed, when potassa is added to a solution of blue vitriol, in quantity sufficient for separating the whole of the sulphuric acid. The disulphate of the protoxide is an insoluble, bluish green powder.

Sulphate of the protoxide of copper and ammonia is formed, by adding ammonia to a solution of blue vitriol, until the subsalt at first thrown down, is nearly all dissolved. It forms a dark blue solution, from which, when concentrated, crystals are deposited by the addition of alcohol. It is the ammoniuret of copper of the pharmacopœia. It contains sulphuric acid, protoxide of copper and ammonia, but their mode of combination is not fully understood.

Sulphate of mercury. Sulphate of the protoxide of mercury is formed, when two parts of mercury are gently heated in three of strong sulphuric acid. If a strong heat is employed and the mixture brought to dryness, a bisulphate of the peroxide results. When this bisulphate (the salt employed in the fabrication of bichloride of mercury), is thrown into hot water, decomposition ensues, and the yellow subsalt, (consisting of 3 equivalents of acid and 4 of the peroxide), called turpeth-mineral, is formed,—the hot water holding some of the bisulphate in solution, together with free sulphuric acid.

Sulphate of soda and lime. This double salt is only known as a mineral production. It is called the glauberite, and occurs crystallized in oblique rhombic prisms.

Alum, (sulphate of potassa and alumina, sulphate of soda and alumina, or sulphate of ammonia and alumina). Alum is frequently found in nature. The sensible properties of alum are the same, whether it contain potassa, soda, or ammonia. It crystallizes in octahedrons. It is soluble in 5 of water at 60° . It has a sweetish astringent taste. On being exposed to heat, the crystals froth up and become anhydrous, forming the alumen usturn of the pharmacopœia. At a full red heat, the alumina is deprived of its acid. Different modes of manufacturing alum.

Iron-alum.—chrome-alum.

Nitrates.—General characters as follows: soluble in water: decomposable at a high temperature, attended by a vivid combustion, when charcoal or other combustible matter is present.

Table of Nitrates.

	Base.		Acid.		Equiv.	Symbol.
Nit. of potassa,	47·15	1 eq.	+54·15	1 eq.	=101·3	KO+NO ⁵
“ soda,	31·3	1 “	+54·15	1 “	= 85·45	NaO+NO ⁵
“ ammonia,	17·15	1 “	+54·15	1 “	{ with water of crystallization.	
“ baryta,	76·7	1 “	+54·15	1 “	=130·85	BaO+NO ⁵
“ strontita,	51·8	1 “	+54·15	1 “	=105·95	SrO+NO ⁵
“ “ in crystals with					45 or 5 eq. of water	=150·95.
“ lime,	28·5	1 eq.	+54·15	1 eq.	= 82·65	CaO+NO ⁵
“ magnesia,	20·7	1 “	+54·15	1 “	= 74·85	MgO+NO ⁵
“ prot. cop.	39·6	1 “	+54·15	1 “	= 93·75	CuO+NO ⁵
“ “ in crystals with					63 or 7 eq. water	=156·75.
“ prot. lead,	111·6	1 eq.	+54·15	1 eq.	=165·75	PbO+NO ⁵
Dinit. prot. “	223·2	2 “	+54·15	1 “	=277·35	2PbO+NO ⁵
Nit. prot. mer.	210·	1 “	+54·15	1 “	=264·15	HgO+NO ⁵
“ “ in crystals with					18 or 2 eq. of water	=282·15.
“ per. mer.	218·	1 eq.	+54·15	1 eq.	=272·15	HgO ² +NO ⁵
Dinit. per. “	436·	2 “	+54·15	1 “	=490·15	2HgO ² +NO ⁵
Nit. silver,	116·	1 “	+54·15	1 “	=170·15	AgO+NO ⁵

Nitrate of potassa (nitre, saltpetre). Generated spontaneously in the soil, and occasionally found in rocks and caves. Artificially produced in nitre-beds.—Theory of nitrification. Crystal, six-sided prism, derived from a right rhombic prism of 120°. Anhydrous. Sp. gr.=1·93. Soluble in 7 of cold water. At 616° it undergoes the igneous fusion, and is decomposed, like other nitrates, at a red heat.

Nitrate of soda (soda-nitre). Found also in the mineral kingdom. Crystal, a rhomboid of 106° 33′. Sp. gr.=2·0. Slightly deliquescent. Soluble in 2 parts of cold water.

Nitrate of ammonia. When the solution of this salt is evaporated at 100°, crystals are obtained, of the same form as nitre; at 212°, fibrous crystals are produced; and if at 300°, a compact, brittle mass, which still contains water: the fibrous variety has 5·2 p. c. of water, the compact variety, 5·7 p. c.;—both varieties

are deliquescent and highly soluble in water. When the salt is heated to 480° or 500° , a rapid decomposition ensues; the hydrogen in the ammonia takes so much oxygen as is sufficient for forming water, the residual oxygen converting the nitrogen both of the nitric acid and of the ammonia into protoxide of nitrogen: 71 grains of the salt will thus yield 44 grains of protoxide of nitrogen and 27 of water.

Nitrate of baryta. Crystallizes in anhydrous octahedra, which require 12 of water, at 60° , for solution.

Nitrate of strontita. Crystallizes like the nitrate of baryta, and is anhydrous. It also is capable of forming an hydrate with 30 p. c. of water, when it assumes the form of an oblique rhombic prism. It is used in pyrotechny.

Nitrate of lime. } Both these nitrates are found in certain
Do. magnesia. } soils, in a deliquescent state.

Nitrate of protoxide of copper. Obtained with difficulty in regular crystals, which possess a blue color. It is strongly deliquescent, and very soluble in water.

Nitrate of protoxide of lead. Anhydrous octahedral crystals.

Nitrates of mercury. Nitrate of protoxide mercury is formed by digesting mercury in nitric acid, diluted with three or four parts of water, until the acid is saturated; and then allowing the solution to evaporate spontaneously in an open vessel, an excess of mercury being left in the fluid. The nitrate of peroxide mercury is formed, when mercury is heated in excess of strong nitric acid.

Nitrate of silver. The solution of this salt, when evaporated, yields anhydrous crystals, which undergo the igneous fusion at 426° , yielding a crystalline mass on cooling; when cast in small cylindrical moulds it forms the lapis infernalis, or lunar caustic, employed as a caustery by surgeons. When heated to 600° or 700° , the salt is decomposed into oxygen, nitrous acid and metallic silver.

Fulminates.

Fulminate of mercury (fulminating mercury).

Fulminate of silver (fulminating silver).

Chlorates.—General characters of, as follows: they deflagrate with inflammable substances, with greater violence than the

nitrates. They are decomposed by a red heat, into oxygen gas and metallic chlorides.

Chlorate of potassa. Presents itself in colorless, tabular crystals or scales, of a pearly lustre. Soluble in 16 of water at 60°. Anhydrous undergoes the igneous fusion at a temperature between 400° and 500°, and on approaching a heat of redness, it effervesces, in consequence of the disengagement of oxygen gas.*

Iodates. } Similar in their general characters to the chlorates.
Bromates. }

Phosphates.—Under this order are included the salts formed by the three isomeric modifications of the same acid, already described as phosphoric, pyrophosphoric and metaphosphoric acids. The compounds they form respectively with particular bases will be referred to, as phosphates, pyrophosphates and metaphosphates.

General properties of the phosphates, as follows: all the protophosphates, which are neutral in composition, are soluble in water; and from their acid reaction, were formerly called superphosphates. The triphosphates are all dissolved by dilute nitric or phosphoric acid, being converted into the soluble phosphates. All the triphosphates with fixed and strong bases bear a red heat, without change. A soluble phosphate may be detected by the yellow, insoluble phosphate of silver thrown down, when nitrate of silver is added. An insoluble phosphate is rendered soluble by ignition in a platinum crucible, with three times its weight of anhydrous carbonate of soda. The solution of the fused mass in water, after neutralization by acetic acid, will afford the characteristic yellow precipitate, on the addition of a few drops of nitrate of silver.

Table of Phosphates.

	Base.	Acid.	Equiv.	Symbol.
Triphos. soda,	93.9	3 eq. + 71.4	1 eq. = 165.3	3NaO + P ² O ⁵
Do. in crystals with	216,	or 24 eq. of water =	381.3.	

* The salt is prepared by transmitting chlorine gas through a concentrated solution of potassa, until the alkali is completely neutralized: a portion of the alkali is decomposed, and chloride of potassium and chloride of potassa are generated. On bringing the solution to the boiling point, the latter compound is decomposed, oxygen gas is evolved, and chlorate of potassa and chloride of potassium are formed. Nine equivalents of chloride of potassa produce one equivalent of chlorate of potassa, eight equivalents of chloride of potassium and twelve of oxygen.

Triphos. soda { Soda, 62·6 2 eq. } + 71·4 1 eq. = 143 { 2NaO, 2HO
& basic water.* { Water, 9· 1 eq. } + P²O⁵

Do. in crystals with 216, or 24 eq. of water = 359.

Do. " 126, or 14 " " = 269.

Acid triphos. { Soda, 31·3 1 eq. } + 71·4 1 eq. = 120·7 { NaO, 2HO
soda & basic { Water, 18· 2 eq. } + P²O⁵
water.

Triphos. { Soda, 31·3 1 eq. } + 71·4 1 eq. = 137·85 { NaOH 4NO
soda & { Ammo. 17·15 1 eq. } + 2HO +
ammon. { Water, 18· 2 eq. } P²O⁵

Bone phos. lime, 228· 8 eq. + 214·2 3 eq. = 442·2 8CaO + 3P²O⁵

Triphos. lime, 85·5 3 " + 71·4 1 " = 156·9 3CaO + P²O⁵

Triphosphate of soda. Slender, six sided prisms. Soluble in 5 of water at 60°.

Triphosphate of soda and basic water. Procured by neutralizing the acid phosphate of lime (obtained from the action of sulphuric acid on calcined bones) with carbonate of soda. The crystals effloresce, on exposure to the air. Soluble in 4 of water at 60°. It is often referred to, as the neutral phosphate of soda, and sometimes also, as the rhombic phosphate. When pure soda is added to its solution, until the liquid feels soapy to the fingers,† the above mentioned triphosphate of soda is formed.

Acid triphosphate of soda and water (biphosphate of soda). It is formed by adding phosphoric acid to a solution of carbonate of soda, or to either of the preceding phosphates, until it ceases to give a precipitate with chloride of barium. The usual form of its crystal is an oblique rhombic prism. Effloresces in the air, and falls to a white powder. Dissolves in 4 of water, at 60°. Taste, much like that of common salt. It is sometimes adulterated with Glauber's salt, when in the efflorescent state. At a red heat, it is converted into metaphosphate of soda.

Triphosphate soda, and ammonia. Prepared by mixing together one equivalent of hydrochlorate of ammonia and two of

* Water is here regarded as playing the part of an alkaline base, and is reckoned as equivalent to one proportional of soda in the composition of the salt.

† The solution must then be evaporated to the crystallizing point, and allowed to cool. The crystals which fall are to be separated, redissolved in water, and crystallized a second time.

the triphosphate of soda, each previously dissolved in boiling water. The salt in question, crystallizes as the liquid cools. This salt has long been known as the microcosmic salt, being much used in blowpipe experiments.

Phosphates of lime. The bone phosphate (the phosphate of lime obtained from bones after their calcination), is the same which is precipitated by pouring chloride of calcium into a solution of the triphosphate of soda and basic water, or by adding ammonia to a solution of any phosphate of lime in acids.

Triphosphate of lime occurs only in the mineral kingdom, constituting the beautiful species known in mineralogy as apatite. It usually occurs in regular hexagonal prisms. Brittle. Sp. gr. = 3.22: and presents almost every shade of color.

Acid triphosphate of lime and basic water (biphosphate of lime). Crystallizes with difficulty: is deliquescent. It exists in urine.

Triphosphate of magnesia and basic water. Formed by mixing hot solutions of the triphosphate of soda and basic water, and sulphate of magnesia.

The phosphate of ammonia and magnesia subsides as a pulverulent, granular precipitate from neutral or alkaline solutions, containing phosphoric acid, ammonia and magnesia. It is readily dissolved by acids, but is slightly soluble in water. It constitutes one variety of urinary concretions; and consists, according to BERZELIUS, of

Phosphoric acid,	-	-	71.4	1 equivalent.
Magnesia,	-	-	41.4	2 "
Ammonia,	-	-	34.3	2 "
Water,	-	-	90.	10 "

Several phosphates in addition to the foregoing, are found in nature, viz. of alumina (wavellite), of magnesia (wagnerite), of alumina and magnesia (lazulite), of alumina and lithia (amblygonite), of yttria (xenotime), of cerium and lantanum (monazite), of iron (vivianite), of manganese and iron (triplite), of lead (pyromorphite), of copper (libethenite and pseudomalachite), of uranium and copper (uranite).

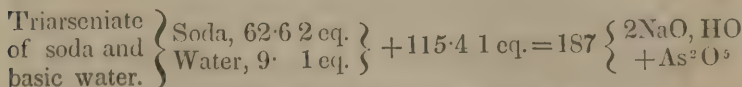
Triphosphate of silver. This subsides, of a characteristic yellow color, when the triphosphate of soda and basic water is mixed in solution with nitrate of silver.

Pyrophosphates.—The most interesting of these are the

Dipyrophosphate of soda and the dipyrophosphate of silver. The latter salt falls as a snow-white, granular precipitate, when solutions of a dipyrophosphate of soda and nitrate of silver are mingled.

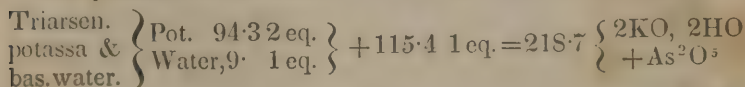
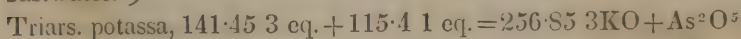
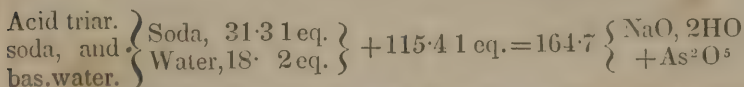
Arseniates.—Those which have two equivalents of basic water, are like the phosphates, soluble in water and possess an acid reaction. They are commonly regarded as bi-salts. When but a single equivalent of water is present (in which case the oxygen of the alkaline base and acid is as 2 to 5), the salt is usually termed a neutral arseniate. If no basic water exists in the salt, it is called a subarseniate.

Many of the arseniates bear a red heat without decomposition, except when combustible matter is present, in which case they are reduced to the metallic state. The soluble arseniates are easily recognized by the tests employed for detecting arsenious acid.



Do. in crystals with 216, or 24 eq. of water = 403.

Do. " " 126, or 14 " " = 313.



Several arseniates are found in the mineral kingdom, viz. that of lime (pharmacolite), of iron (cube ore), of cobalt (cobalt-bloom), of nickel (nickel-green), of copper (copper-mica, aphanesite and euchroite), of lead (mimetine), of copper and iron (skorodite).

Arsenites.—The arsenites of the alkalis are very soluble. All of the arsenites are decomposable, when heated in close vessels. When ignited with charcoal or black flux, the acid is reduced to the metallic state. The soluble arsenites form a yellow arsenite of silver, when mingled with a solution of nitrate of silver; and a

green arsenite of copper (Scheele's green), with sulphate of protoxide of copper. The arsenite of potassa is the active ingredient in Fowler's solution.

The diarsenite of sesquioxide of iron is insoluble; hence the administration of hydrated sesquioxide of iron as an antidote for arsenious acid.

Chromates.—Remarkable for rich colors, which are mostly, either yellow or red. On boiling a chromate in hydrochloric acid mixed with alcohol, the chromic acid is decomposed, and a green solution of the chloride of chromium results.

Chromate of potassa. Crystals have a right rhombic prism, as their primary form. Color, lemon-yellow. Soluble in 2 of water, at 60° .

Bichromate of potassa. Of a rich red color, and soluble in 10 of water, at 60° .

Dichromate of potassa. Of a cinnabar-red color.

Chromate of lead. As prepared by the chemists, it is a rich yellow powder, insoluble in water, and known in the arts, as chrome-yellow. It occurs however, as a beautiful mineral, called red lead-ore, in the form of an oblique rhombic prism, of $93^{\circ} 30'$. Color, hyacinth-red. Sp. gr. = 6.00.

Chromate of lead and copper. The vauquelinite of the mineral kingdom. Color, olive-green. Sp. gr. = 5.5.

Borates.—The borates of the alkalies are soluble in water. None of the borates are decomposable by heat. They are remarkable for their easy fusibility, and for imparting this property to other bodies. They are distinguished from other salts, as follows: digest any borate in a slight excess of strong sulphuric acid, evaporate to dryness, boil the residue in strong alcohol; the solution of boric acid obtained, will burn with a green flame.

Biborate of soda (borax). Found dissolved in certain lakes of Thibet and Persia. It crystallizes from the concentrated solution, in oblique rhombic prisms of $93^{\circ} 30'$. Sp. gr. = 1.71. Soluble in 20 of water at 60° . Taste, feebly alkaline and sweetish. The crystals contain ten equivalents of water, of which they may be deprived by heat, when they form a vitreous, transparent substance, called glass of borax.

Biborate of magnesia. A rare mineral, called boracite. Primary form of crystal, the cube. It has the hardness of rock-crystal. Sp. gr. = 2·97.

Silicates.—A numerous and important order of salts, nearly all of which are natural products. With the exception of the silicates of potassa and soda, they are insoluble in water. Most of them also, are not attacked by the strong acids, unless subjected in fine powder for some time, to their action. They are all decomposed however, by being ignited in a state of powder, with three times their weight of carbonate of potassa or soda.

Silicates of potassa and soda. The liquor silicum of the ancients appears to be a silicate of potassa. It is formed by fusing together, one of silicic acid and three of hydrated potassa. It is soluble in water. The so called, soluble glass does not differ sensibly, from the liquor silicum. It is formed by fusing together in a clay crucible for five hours, 10 of carb. potassa, 15 of powdered quartz, and 1 of charcoal. The solution of the fused mass, when concentrated to a sp. gr. of 1·25, and mingled with finely levigated chalk, bone-ashes, clay, glass, &c., forms a preparation, which is useful for rendering cloth, wood, or paper, incombustible. Silicate of soda possesses, properties similar, with those of silicate of potassa. It forms a transparent, colorless glass, which is soluble in boiling water.

By subjecting silicic acid and potassa or soda, to very high temperatures, supersilicates of these alkalies are formed; which are insoluble in water, and known as common glass. Other bases, however, generally enter into the composition of glasses: hence the following classification.

Crown-glass,—silicate of potassa and lime.

Window and mirror-glass,—silicate of soda and lime, sometimes also of potassa.

Bottle-glass,—silicate of soda, lime, alumina and iron.

Flint-glass,—silicate of potassa and lead.

The sp. gr. of glass varies, from 2·3 to 3·6. The lightest kind consists of silica and potassa; that with lime is rather heavier, while that with oxide of lead is the heaviest of all.

Table of the composition of different kinds of glass.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Silicic acid,	71·7	62·8	69·2	59·2	51·93
Potassa,	12·7	22·1	8·	9·0	13·27
Soda,	2·5	0·	3·	0·	
Lime,	10·3	12·5	13·	0·	
Alumina,	4	0	3·6	0·	
Magnesia,	0	2·6	0·6	0·	
Oxide of iron,	3		1·6	0·4	
“ manganese,	2			1·0	
“ lead,	0			28·2	33·28

No. 1 is white Bohemian glass.

“ 2 “ “ crown-glass.

“ 3 is green phial-glass.

“ 4 is English glass, for chemical apparatus.

“ 5 is “ flint-glass.

Pottery, earthen ware, porcelain, &c. These consist essentially of silicic acid and alumina: the proportions of which vary in different fabrics, as may be seen in the following table of various wares :

	No. 1.	No. 2.	No. 3.	No. 4.
Silicic acid, - - -	70·9	77·6	60·	82·0
Alumina, - - -	24·8	19·	35·3	9·1
Magnesia, - - -		2·8	1·8	7·4
Ox. of iron, - - -	3·8	0·3	2·5	0·0
Lime, - - -	0·0	0·0	0·0	1·3

No. 1. Hessian crucible. 2. Brick. 3. Sevres porcelain. 4. English porcelain.

Glazing for earthen ware and porcelain. Glaze for common cream-colored English ware is composed of 53 white lead, 16 feldspar, 36 ground flints, and 4 of flint-glass. Glaze for covering all kinds of figures printed in metallic colors: 26 feldspar, 20 white lead, 6 ground flints, 4 chalk, 1 oxide of tin, and a small quantity of cobalt to take off the brown cast, and give a faint azure tint. Glaze for English porcelain; feldspar 45, flints 9, borax 21, flint glass 20, nickel 4, red lead 12. Glaze of Sevres porcelain is composed solely of feldspar, which is calcined, crushed, and then ground to an impalpable powder in a mill.*

* The cheapest kind of stone ware is often glazed by volatilizing common salt in the baking ovens, whereby a glazing of silicate of soda is formed upon the surfaces of the articles. Such goods are well adapted to withstanding the corrosive action of acids.

Silicates of the mineral kingdom.

Silicate of lime. Tabular spar.

Silicates of magnesia (with water). Talc, serpentine.

Silicate of alumina. Kyanite.

“ glucina. Phenakite.

“ zirconia. Zircon.

“ manganese. Red manganese.

“ copper (hydrated). Chrysocolla, diopase.

Silicate of alumina and potassa. Feldspar, leucite.

“ “ and soda. Albite, analcime.

“ “ and baryta (hydrated). Harmotome.

“ “ and lithia. Petalite and spodumene.

“ “ and lime. Scapolite.

“ “ “ (hydrated). Prehnite, mesotype,
heulandite, thomsonite, stilbite, laumonite and chabasie.

Silicates of alumina and glucina. Beryl, euclase.

Silicate of lime and potassa (hydrated). Apophyllite.

“ “ and iron. Yenite.

“ of alumina, lime and iron. Epidote.

“ “ “ and potassa. Pyroxene.

“ “ “ “ and iron. Hornblende.

“ “ “ iron and manganese. Garnet.

“ “ lithia, iron and potassa. Mica.

CHLORINE-ACID SALTS.

Hydrochlorate of ammonia (muriate of ammonia, or sal-ammoniac). Formerly procured by sublimation, from the soot of camel's dung; but at present is largely made by extracting sulphate of ammonia from soot, this salt being mingled with common salt, and subjected to heat in globular glass vessels, on the upper side of which the sal-ammoniac forms, in cakes. It occurs in small quantity, as a mineral production in the vicinity of volcanoes. Crystal derived from a cube. Sp. gr. = 1.45. It sublimes at a temperature below ignition, without fusion or decomposition. It is soluble in 3 of water, at 60°. Its taste is acutely pungent.

Chloro-stannates.

Chloro-stannates of ammonia. Both of the chlorides of tin possess the characters of an acid, and are capable of combining with bases. They are formed by mingling concentrated solutions

of the chlorides respectively, with solution of hydrochlorate of ammonia.

Chloro-stannate of potassium.

Chloro-hydrargyrate.—The bichloride of mercury combines also with other chlorides, forming an order of salts.

Bichloro-hydrargyrate of ammonia. Formed by mixing solutions of sal-ammoniac and corrosive sublimate. It was known to the alchymists under the names of sal-alembroth, salt of wisdom, or salt of art.

Chloro-hydrargyrate of potassium.

“ magnesium.

“ iron.

Chloro-aurates.

Bichloro-aurate of potassium. Formed by mingling solutions of chloride of gold and chloride of potassium. Crystals, yellow four sided prisms: highly-soluble in water.

Chloro-aurate of sodium.

Chloro-platinates.

Chloro-platinate of ammonia.

“ potassium.

“ sodium.

Chloro-palladiates.

BROMINE-ACID SALTS.

Hydrobromate of ammonia.—In long, white crystals. Volatilized by heat.

Bromo-hydrargyrate.

Bromo-hydrargyrate of ammonia.

“ potassium.

IODINE-ACID SALTS.

Hydriodate of ammonia.—Crystallizes in cubes. Sublimes without decomposition. Deliquescent and soluble in water.

Iodo-hydrargyrate.

Iodo-hydrargyrate of potassium.

“ sodium.

“ iron.

FLUORINE-ACID SALTS.

Hydrofluat of ammonia.

Fluo-borates.

Fluo-silicates.

Fluo-columbates.

Fluo-titaniates.

CYANOGEN-ACID SALTS.

Hydrocyanate of ammonia.

SULPHUR-ACID SALTS.

Hydrosulphate of ammonia (fuming liquor of Boyle). Formed by passing a current of hydrosulphuric acid through aqua-ammonia. It constantly emits white fumes, possessed of a fetid odor.* It is much employed as a chemical test.

Hydrosulphate of potassium.

“ sodium.

“ barium.

“ strontium.

Bisulpho-carbonates.—The acid of these sulphur-salts is the bisulphuret of carbon.

Sulpho-arseniates.

Sulpho-arsenites.

Hydrosulpho-arsenites.

Mobybdo-sulphates.

Antimonio-sulphates.

Tungsto-sulphates.

Sulpho-tellurates.

GALVANISM.

The force of affinity is not only excited by the contact of dissimilar kinds of matter and expends itself at the surfaces where it originates, but we have it in our power to cause this same force to travel to a distance, and to act at points far removed from that at which it is excited or generated. The impulse must be given and maintained by the contact of dissimilar particles of matter.

Construction of the simple circuit by means of a plate of zinc and one of silver, partly immersed in dilute sulphuric acid.—No action ensues while the plates are kept separate. When they touch, or when the connexion is effected by means of some good conductor of electricity, the zinc immediately begins to decompose the water, by taking its oxygen, in consequence of the

* It was proposed by Mr. CRUKSHANKS as a remedy in diabetes mellitus.

affinity by which it attracts it, being superior to that by which the oxygen is combined with hydrogen in water: the hydrogen is given off in bubbles from the silver plate.*

Explanation of the manner in which the electrical excitement is produced.

If the communication between the two plates be made by means of a metallic wire, it is found that the conducting wire is in a state of activity as regards temperature and magnetism, while transmitting the impulse. Galvanometer.

Substitution of a portion of the moist structure of an animal, for the conducting wire.—Discovery of GALVANI.

Transfer of elements. No visible transfer of the oxygen and hydrogen takes place, during the action of the circuit, nor does any impediment arise to their separation, provided the vessel which contains the acid water be divided by a partition of bladder (the zinc plate being left on one side and the silver on the other), porous earthen ware, or other substance, capable of imbibing the liquid. The generated force is spoken of, as an invisible current, setting from the zinc through the liquid to the platinum, and back again (out of the liquid) through the wire to the zinc.

The zinc plate is the generating plate, while the platinum one only acts as a conductor of the force.

If plates of a given extent of surface, instead of being immersed in one cell of liquid, be cut into several equal pairs and placed in separate cells, and all the plates of each kind be connected together by a metallic wire, no action will ensue until the two series also are connected together, by another wire; when the amount of circulating force will be found to be the same as before.

The direction of the current depends upon the nature of the chemical action which is produced, at the period of its passage. Thus, if a plate of iron and one of copper be immersed in hydro-

* The oxide of zinc is removed,—a combination with the sulphuric acid forming with it the sulphate of zinc, or white vitriol, which enters into solution as fast as the compound is formed. The decomposition of the water and the composition of the white vitriol take place, in accordance with laws of definite proportions already explained: for example, 32 parts or 1 equivalent of zinc combine with 8 parts, or 1 equivalent of oxygen. 40 parts or one equivalent of oxide are taken up by 40 parts, or 1 equivalent of sulphuric acid: and 1 part of hydrogen, or 1 equivalent is evolved by the decomposition of 9 parts, or 1 equivalent of water (of which the 8 parts of oxygen unite with the zinc).

chloric acid, the action is altogether on the iron, and the current passes from the copper to the iron, at the point of contact out of the liquid ; but if the plates be immersed in a strong solution of ammonia, which acts upon the copper, but not upon the iron, the current is produced in the reverse direction. If persulphuret of lime, dissolved in water, be used as the exciting fluid with iron and copper, the current is from the copper to the iron, through the fluid ; but on using zinc and copper with the same fluid, the direction of the current is reversed. In the first case, the copper, and in the last, the zinc, is acted on.

Metals may be arranged in columns with relation to different fluids (placed at their head), in which, if they be immersed and brought to touch outside, a current will be generated from that of the two metals which stands highest in the series to that which is below ; the current from one to the other in the parts below the fluid, being in an opposite direction.

Dilute nitric acid.	Strong nitric acid.	Hydrochloric acid.	Solution of potassa.	Hydrosulphuret of potassium.
Platinum	Platinum	Platinum	Platinum	Platinum
Silver	Nickel	Antimony	Silver	Iron
Copper	Silver	Silver	Nickel	Nickel
Antimony	Antimony	Nickel	Copper	Bismuth
Bismuth	Copper	Bismuth	Iron	Antimony
Nickel	Bismuth	Copper	Bismuth	Lead
Iron	Iron	Iron	Lead	Silver
Tin	Tin	Lead	Antimony	Tin
Lead	Lead	Tin	Cadmium	Cadmium
Cadmium	Zinc	Cadmium	Tin	Copper
Zinc	Cadmium	Zinc	Zinc	Zinc

It will be seen that the metals arrange themselves very differently with different fluids, according to their liability to chemical action from them. The current will be more powerful in proportion as the metals are remote from each other in the list ; thus with dilute nitric acid, the most powerful current is from platinum to zinc.

A second zinc plate cannot perform the functions of a conducting plate to the first, because it will itself tend to generate a current of exactly equal power, in the opposite direction.

Any metal which has a stronger affinity for oxygen than platinum, provided it be less than that of zinc, may be substituted for

it. Thus copper, when opposed to platinum, is capable of generating a feeble current; but when opposed to zinc, will become an efficient conducting plate. Its attraction however, for oxygen, though counteracted, will act as an antagonist force, and check the current.

Another antagonist to the galvanic current, is the disengaged hydrogen which adheres to the conducting plate, but this opposing force may be removed by the addition to the liquid of a little nitric acid, which will prevent the evolution of the hydrogen, at the same time occasioning an increased activity in the current, as is proved by the augmented heating and magnetic powers of the conducting wire. This increased energy is ascribable to new decompositions and recompositions from the presence of the nitric acid, which being decomposed, yields a portion of its oxygen to the hydrogen liberated from the water, whereby water is reformed; while the other element, the nitrogen of the nitric acid, unites with another portion of the hydrogen to produce ammonia.

The hydrogen may also be removed by the action of metallic oxides; for when under the restraint of adhesion, it is capable of deoxidating and reducing the metals from their saline solutions. To effect this to the best advantage, divide the cell for the liquid into two equal parts by a diaphragm of bladder, and add a solution of sulphate of copper to that division which contains the conducting plate; the current will proceed with increased energy, and the hydrogen will be completely removed, in virtue of its affinity for the oxygen of the oxide of copper in the solution, with which it forms water, the plate at the same time becoming coated by copper.*

All the decompositions and compositions which take place in the generation of the galvanic current, are in exact accordance

* An ingenious application has been made of the electrical precipitation of copper, in taking the casts of medals. A concave copy of the medal is first obtained, in fusible metal or lead: the back of it is then soldered to a copper wire, immersed in sulphate of copper solution, to the other end of which is soldered a mass of zinc, immersed (together with a part of the copper wire) in weak acid. Those parts of the cast, not intended to receive a coating of the precipitated copper, are protected by bees'-wax.

with the laws of definite proportion. For every 32 grs. of zinc expended in the generation of the force, 40 grs. of oxide of zinc, and 80 grs. of sul. copper are formed, and 40 of oxide of copper are decomposed; and 32 of metallic copper are precipitated, by the combination of 8 grs. of oxygen with 1 gr. of hydrogen.

The force of the current is in proportion to the amount of these compositions and decompositions, which take place in a given interval of time, as is proved by the effects produced on the galvanometer.

The circulating force wholly depends upon the decomposition of the water, and the composition of the oxide of zinc,—the sulphuric acid only acting to remove the latter. The affinities of other substances may be substituted for water, as hydriodic or hydrochloric acid, in which cases, iodides or chlorides of zinc will be formed, and their hydrogen directed to the conducting plate.

But chemical affinity, however strong, cannot produce a current unless accompanied by decomposition.

The divellent substance must be a conductor of electricity in order to establish the electric current.

“The same metal may perform the functions both of a generating and conducting plate, provided one portion of its surface is immersed into a liquid, which it is capable of decomposing, while another is plunged into a liquid to which it is indifferent, both liquids being also in contact with each other.”

When a solution of hydrochlorate of ammonia is placed in the decomposing cell, having mercury in contact with the platinum plate, the mercury in the course of a few hours will swell up to five or six times its original bulk, and present a buttery consistence, like a metallic amalgam. On immersing the soft metal in water, hydrogen is evolved, the mercury returns to its former state, and a solution of ammonia is obtained. Explanation of these phenomena.

Influence of variations in the relative size of the generating and conducting plates upon the amount of force thrown into circulation.

Sir H. DAVY's invention to prevent the corrosion of copper-sheathing on ships.

Different arrangements of the generating and conducting metals in galvanic apparatus:—concentric spheres, i. e. a solid sphere of a generating metal, surrounded by a hollow one of an inactive conducting metal, with an intervening liquid, capable of decomposition by the former, and not by the latter,—the circuit being completed by a conducting wire, for connecting the two metals.

Next in simplicity to the foregoing arrangement, is a rod of zinc within a cylinder of copper; the rod being placed in a membranous cell charged with acid, and the remainder of the cylinder being occupied by a solution of sulphate of copper. The amount of circulating force is the same as in the spherical arrangement, at the same time that it greatly surpasses it in convenience.

Thus far, the arrangements described, have had one part of the circuit, consisting of a liquid compound, opposing the transmission of the force in proportion to the thickness of the stratum which it has to traverse, and the other of a metallic conductor, the opposition of which is scarcely appreciable, in the comparison. It may now be inquired, whether a second portion of a compound liquid might not be substituted for the conducting wire, in closing the circuit. If two cells are connected together in such a way, that the zinc plate of one is in metallic communication with the zinc plate of the other, and the platinum with the platinum, it is clear that each generating plate would tend to form a current; and the two as regards a circuit would be in opposite directions. The force which would be transferred from the zinc to the platinum of the first, can only return by passing from the platinum to the zinc of the second, and is balanced by the tendency of an equal force to pass from the zinc to the platinum of the same cell.

“If we remove all active tendency in one of the cells, by the substitution of a second platinum plate for the zinc, still the current of the other, will not be able to force its way; for it can only pass from the conducting plate to which it must be consigned by the first portion of liquid, by the decomposition of the second portion of liquid and the transfer of the force from particle to particle; and the affinity of the oxygen and hydrogen has to be overcome. The divellent force which tends to pass, is only equivalent to that

which unites the particles of oxygen and hydrogen together, and therefore insufficient to overcome that force in the quiescent state."

But if in the second cell, we interpose some liquid compound between the plates, whose constituent particles are held together by an affinity of a lower degree of intensity than those of the first liquid, the superior force will overcome the inferior and the current will be established. The amount of force which will make its way against the opposing affinity is far below that which circulates, when a metallic path is opened for it: and if, instead of connecting together the two zinc plates and the two platinum, each zinc be connected with the platinum of the other, the circuit will be complete, and the force will circulate with increased energy. Any number of cells may be thus connected by their alternate generating and conducting plates; but no effect will ensue until the conducting plate of one end of the series is put in communication with the generating plate of the other end, when the force will circulate with an intensity proportionate to the number of cells.

If instead of a battery with generating and conducting plates arranged in the proper order, one be substituted, having a pair of reversed plates interposed in a circuit of ten alternations, the current will be checked, but not stopped in its course; it will pass through the reversed cell, with the decomposition of the liquid,—the oxygen, however, being evolved upon the zinc, and the hydrogen upon the copper plate, in opposition to the strong affinity of oxygen for zinc. Indeed, the current will be able to overcome a number of such obstructions, proportionate to the number of concurring cells.

"The force, in this state of intense activity, will also overcome obstacles of a different nature. Whatever the quantity may be which is set in circulation, though sufficient to ignite and fuse platinum wire, the slightest break in the continuity of the conductor will stop the current; but when its energy has been elevated by the repeated impulses of a series, it will project itself through an interval of air or water, in the form of an intense electric arch, and thus complete its circuit."

Any obstruction in one of the cells of a circuit, composed of numerous alternations, reacts upon the whole; and no inequality

can possibly exist in different portions of the current, whether in its passage through the liquid or the solid conductors. If the action be retarded one third or one tenth in a single cell of a circuit, an equal retardation will take place throughout; unequal quantities of force cannot be generated and circulated in different parts of the same circuit.

When one of the zinc plates is removed from the regular series, and replaced by a platinum plate which has been previously coated with copper (by the influence of hydrogen evolved in a circuit), no gas will at first be evolved from the coppered plate; but it will oxidate, as may be seen by the gradual blackening of its surface. The oxide again will be gradually dissolved, and the bright white surface of the platinum will make its appearance, and oxygen gas will begin to rise from it. At that moment, the current will receive a check, which will be appreciable in all the cells. This mode of measuring the amount of current affinity by its chemical effects, has been applied in the construction of instruments called Volta-meters. They consist of an independent, closed cell, with two platinum plates, from which the gas may be conveniently collected and measured. They may be included in any circuit, and although they check the current in all its parts, they accurately measure the amount which passes through them.

“By observations made with the Volta-meter, it is found that the action of a compound circuit is not constant, but that it gradually declines after an interval of about five minutes. By breaking the connexion for a short period, its energy will be partially recovered, but will again decline as the action is renewed. Upon allowing the charge nearly to exhaust itself, it will be seen that the platinum plates have become incrustated with metallic zinc, originating doubtless from the oxide of zinc formed at the generating plates, and reduced by adhering hydrogen at the conducting plates. Its varying quantity and accumulation are amply sufficient to account for the variation and ultimate annihilation of the circulating force; for zinc thus becomes opposed to zinc, and the circuit is destroyed. The momentary breaking of the connexion, allows the acid to dissolve off the zinc, which being in contact with the conducting metal, is most favorably disposed for this local action, and upon restoring it, the circulation returns to its original state, but again declines as in the first instance, and from the same cause.”

Voltaic pile.—Couronne des tasses. CRUIKSHANKS' trough.—Do. as improved by Dr. BABINGTON and Dr. WOLLASTON.—Constant battery of Prof. DANIEL.—Deflagrator and calorimotor of Dr. HARE.

According to VOLTA, the source of galvanic electricity is the contact of dissimilar metals, the interposed liquid being regarded only in the light of an imperfect conductor; but from the experiments of FARADAY it appears, that the contact of dissimilar metals is not necessary to the production of the voltaic current, and that the force is exactly proportioned to the amount of chemical action. It is not denied that electricity is developed by the contact of dissimilar metals; but it is small in quantity, of high intensity and intermitting in its action; to generate a current, the contact of a compound liquid with a metal, seems to be necessary.

The identity of circulating affinity (or voltaic electricity) with electricity. The water battery.—The column of De LUC.

"The charged particles which travel in the carrying discharge of common electricity, may be considered as masses of matter, large or small, simple or compound; and they move towards other masses of matter in which they have produced the opposite state, by the induction and polarization of intervening particles. The convection of the voltaic charge however, differs inasmuch as it can only be effected by the separation of the constituent particles of bodies in certain equivalent proportions, from compounds in which they had been previously combined, and they move also under the influence of the same kind of polarity previously induced. This forced condition never reaches a high degree of intensity, because it is constantly relieved by the yielding of the compound.

"The simplest case of this convection is presented to us, when the current is led from a series of generating cells into an inactive cell, through which it has to force its passage without the assistance of any concurring affinity. The plates by which it passes into and out of the liquid, have been denominated electrodes, as being the doors by which the current enters and departs. They have further been distinguished as the zincode, and the platinode, the former, being the plate which occupies the position of the generating plate in the battery, and the latter, the conducting plate.

Through the intervening stratum of water, rendered conductive by sulphuric acid, it can only pass by convection and decomposition of the water. For this, the particles of oxygen and hydrogen travel in opposite directions, separating from one, and recombining with another, throughout the series of previously polarized particles, till the last particle of hydrogen gives up its charge to the platinode, and the oxygen to the zincode, and each passes off in its own elastic form. The convection, therefore, cannot be regarded in the transfer of a single force in one direction, but of two forces in opposite directions, and hence the electric current, whether in metals, or liquids, or air, has been designated as an axis of power having contrary forces, exactly equal in amount in contrary directions.

“The polarity of the arrangement, when in a state of action, is well illustrated by interposing between the electrodes a plate of platinum; its side fronting the zincode will give off hydrogen, and the opposite side the equivalent oxygen. If a plate of copper be substituted for the platinum, and sulphate of copper be added to the electrolyte, the first will be coated with fresh precipitated copper, and the second oxidated and dissolved to exactly the same amount. The current which enters by the zincode, is conveyed by the electrolyte to the metallic diaphragm, to which it gives up its charge; it then re-enters the electrolyte on the other side, and passes on to the platinode; and the opposite face of the plate exhibits that opposition of forces which characterizes the process.

“The same kind of convection takes place in the generating cells of the battery; but the combination of the disengaged elements at the two electrodes, not only removes a strong opposing force, but perpetually renews the heterogeneous contacts by which the current is generated, exalted and maintained.”

Electrolysis is the process of resolving a compound into its elements, by means of the voltaic current: substances capable of such decomposition being called electrolytes.

Liquidity an essential condition of electrolysis.

The direction taken by the disengaged elements, or principles of electrolytes under the influence of the current.—In the decomposition of water, the oxygen, from its natural affinity, must travel

from the conducting plate towards the zinc, and the hydrogen in the opposite direction. The elements or principles of any other electrolyte will follow the same law : i. e. those elements having the greatest attraction for the zinc, will take the path of the oxygen, and appear at the zincode, and their associates, travelling in the opposite direction, will escape at the platinode. Thus among the elementary substances, chlorine, bromine, iodine and fluorine range with oxygen, and the metals with hydrogen ; and amongst secondary compounds, cyanogen and acids rank with the former, and alkalies and protoxides generally with the latter.

These classes of bodies and certain particulars relating to their decomposition, have been distinguished by a nomenclature invented by FARADAY, and derived from the direction of the current, which is supposed to pass through the circuit, and which is indicated by the direction of the magnetic needle, under the influence of the earth. Thus, if in any case of electrolysis, we consider the decomposing body placed so that the current passing through it shall be in the direction that the sun appears to move in, or from east to west, then the surfaces at which the electricity is passing into or out of the substance, would have an invariable reference to the points of the compass, and exhibit constantly the same relation of powers. He therefore calls that towards the east the anode, and that towards the west the cathode. The anode is that surface of the electrolyte at which the current is supposed to enter, and which is in contact with the zincode, and is where oxygen, chlorine, acids, &c. are evolved. The cathode is that surface of the decomposing body at which the current leaves it, and is in contact with the platinode ; it is the place where hydrogen, the metals, alkalies, &c. are evolved. Those bodies which go to the anode of the decomposing body, are called *anions*, while those passing to the cathode are *cations*. When these bodies are spoken of together without distinction, they are simply called *ions*. Thus the electrolyte, chloride of lead, when electrolyzed, evolves two ions, chlorine and lead, the first of which is an anion, and the second a cation.

The chemical action of a current of electricity is definite and directly proportionate to the absolute quantity of electricity which circulates : thus, when fused protochloride of tin, chloride of lead,

and water, are placed in succession, and decomposed simultaneously by the same electric current, the tin and the chlorine at the first pair of electrodes, are respectively in the proportion of 58 to 36, the lead and the chlorine at the second, as 104 to 36, and the hydrogen and the oxygen at the third, as 1 to 8.

As the decompositions dependent upon the current which sets through the experimental cells are definite, so are the compositions and decompositions which are associated with the current in the battery cells; and it requires the combination of 32 grs. of zinc with 8 of oxygen, abstracted from 9 of water, in each of the cells, to generate the current, which is carried forward by the equivalent quantities of the different kinds of matter specified above.

The electricity which is evolved by the decomposition, and that which decomposes a certain quantity of matter, are alike: and hence the equivalent weights of bodies are simply those quantities of them which contain equal quantities of electricity, or have naturally equal electric powers; it being the electricity which determines the equivalent number, because it determines the combining force.*

All compounds are not susceptible of electrolyzation, even in the liquid state.

* The specific electricity of different substances is inversely as their atomic weights; and a given quantity of electricity will separate from combination, portions of substances represented by their combining (atomic) weights. Thus the action of 32 parts of zinc in a voltaic battery, is able to evolve a current of electricity which is capable of decomposing and transferring the elements of 9 parts of water, and of disengaging 1 part of hydrogen and 8 of oxygen. It thus appears, that the combining weights of bodies derived from chemical analysis agree with those which are obtained by electrical decomposition.

Table of electro-chemical equivalents.

CATIONS.			ANIONS.		
	Equiv.	Specif. elec.		Equiv.	Specif. elec.
Hydrogen,	1.	1000	Oxygen,	8.	125
Potassium,	39.2	25	Chlorine,	35.5	27
Sodium,	23.3	43	Iodine,	126.	8
Zinc,	32.5	31	Bromine,	78.3	12
Copper,	31.6	31	Fluorine,	18.7	55
Ammonia,	17.	58	Cyanogen,	26.	38
Potassa,	47.2	21	Sulphuric acid,	40.	25
Soda,	31.3	32	Nitric acid,	54.	18
Lime,	28.5	35	Chloric acid,	75.5	13

A substance cannot be transferred by the voltaic current beyond the point, at which it ceases to find particles, with which it may combine; but an acid will traverse any portion of alkali interposed in its passage, towards an electrode (or vice versa), unless the acid should form with the alkali (as in the case of sulphuric acid and baryta), an insoluble compound, when the liquid state being lost, no convection can take place.

Primary and secondary character of decompositions.

Table to illustrate the intensity, of chemical affinity as determined by the facility of electrolysis,—those which are placed first being decomposed by the current of lowest affinity.

Iodide of potassium (solution).

Chloride of silver (fused).

Protochloride of tin (fused).

Chloride of lead (fused).

Iodide of lead (fused).

Hydrochloric acid (solution).

Water acidulated with sulphuric acid.

A voltaic current may pass in very small quantity through an electrolyte, without decomposing it.

Electricity of the machine is capable of producing electrolytic effects, in proportion to its quantity.

The quantity of electricity required to decompose a small quantity of a compound body, is very great. Two wires, one of platinum and one of zinc, each $\frac{1}{16}$ of an inch in diameter, placed $\frac{5}{16}$ of an inch apart, and immersed to the depth of $\frac{5}{8}$ of an inch in acid (consisting of one drop of oil of vitriol and 4 oz. distilled water) at 60° , and connected at the other extremities by a copper wire, 18 feet long and $\frac{1}{8}$ of an inch in thickness, yielded as much electricity in little more than three seconds of time, as a Leyden battery exposing a surface of 3500 square inches, charged by 30 turns of a plate-glass machine, 50 inches in diameter, in full action. This quantity, though sufficient to have killed a cat, if passed at once through its head, was evolved by the mutual action of so small a portion of the zinc wire and water in contact with it, that the loss of weight sustained by either, was wholly inappreciable. And by carrying out the calculation, it would appear, that 800,000 such charges of the Leyden battery would be neces-

sary, to supply electricity enough to decompose a single grain of water ; a quantity which would be equal to a very powerful flash of lightning ; but which in an infinitely lower state of tension, would be supplied in $3\frac{3}{4}$ minutes, by an electric current capable of keeping a platinum wire $\frac{1}{104}$ of an inch in thickness, red hot.

Voltaic flame.—Deflagration.

Conducting power of metals.

Table.

Copper,	-	100.	Platinum,	-	16.4
Gold,	-	93.6	Iron,	-	15.8
Silver,	-	73.6	Tin,	-	15.5
Zinc,	-	28.5	Lead,	-	8.3

Conducting power of solutions.

Table.

Saturated solution of sulphate of copper,	-	1.
Do. diluted with 1 volume of water,	-	0.64
Do. do. 2 “ “	-	0.44
Do. do. 4 “ “	-	0.31
Saturated solution of sulphate of zinc,	-	0.417
Distilled water,	-	0.0025

Thermo-electricity.—“If a platinum wire be carefully soldered to the two extremities of a delicate galvanometer, and it be heated at any remote point from the junctions, no disturbance of the electric equilibrium will be produced : from the homogeneous structure of the wire, the heat will flow equally to the right and left of the heated point. But it will be very different, if a knot or spiral turn be made in the wire without breaking it ; for if the focus of heat be applied to the right of such obstruction, an electrical current will be established from right to left, as will be indicated by the needle. This must arise from the unequal rate at which the heat will be propagated on the two sides of the obstructing mass. Wires of copper and silver will act in the same way, but in an inferior degree. The same effect will be produced, if the wire, instead of being continuous, be divided, and each end being twisted into a spiral to increase the surfaces, one be heated red in a spirit lamp, and brought into contact with the other.”

These effects are still more striking in those metals having a crystalline texture, from the unequal conduction of heat through their masses. In a rectangle, cast of bismuth or antimony, three or four inches across, the substance of which being about one third of an inch in diameter, on being cooled by ice at one end and heated at the other, a current of electricity will be immediately established.

Thermo-electric effects are much increased by combinations of two metals.

Electro-magnetism.—Iron-filings adhere to the conducting wire of a voltaic battery in action, presenting the appearance of a closely compacted layer, instead of that bristled arrangement, visible when filings are thrown upon a bar-magnet. When the circuit is interrupted in any part, the filings immediately fall off and return to their natural state. When a magnetic needle is placed under the conducting wire of a battery, and parallel with it, there is a tendency in the needle to arrange itself at right angles to the wire,—the direction of the magnetic poles always having a constant relation to the direction of the voltaic current.

The conducting wire produces no effect upon needles of brass, or other non-magnetic metal.

Electro-magnetic effects depend upon the size of the conducting surface in the battery.

The magnetic force of the conducting wire acts by induction upon iron and steel: and the intensity of the action is greatly augmented by coiling the wire in such a way, as to bring many portions of the same side to bear upon one point. This spiral conformation of the wire is denominated a helix. According as the turns of such an helix are directed from right to left, or from left to right (or in the manner of a right-handed or left-handed screw), the upper or the under side of the originally horizontal wire will be turned inwards, and the direction of the accumulated force will vary accordingly. To prevent direct communication between the coils of the wire, in experimenting with such an arrangement, the conducting wire is covered with silk; or it is twisted round a glass tube, whereby the electric influences are insulated, while a free passage is allowed to the magnetic. A steel needle, placed in the axis of such a cylinder, becomes at once a permanent magnet.

Electro-magnetic induction also takes place temporarily, in soft iron. To effect this, the horse-shoe magnet is wound around with a coil of copper wire, which has itself been previously covered with silk; and a current from a moderate sized battery, is transmitted through the wire. The horse-shoe instantly becomes powerfully magnetic. When the circuit is broken, the magnetism ceases; but if, instead of breaking the connexion with the battery, the electric poles be changed, so as to reverse the direction of the current, the poles of the magnet are charged with the utmost rapidity. The weight momentarily separates from them, but is instantly again attracted, and sustained with the same force as before.*

Electro-magnetic rotation.

Electro-dynamic cylinders.

AMPERE's hypothesis of magnetism.

Magneto-Electricity. If a wire connecting the two ends of a delicate galvanometer be placed close to, and parallel with, the wire connecting the poles of a voltaic battery, no effect will be produced upon the needle. If the surfaces opposed in the two wires be increased, by coiling the one as a helix within a helix formed out of the other, both being covered with silk to prevent metallic contact, still no effect will take place until the current of the battery is stopped by breaking the circuit, when the needle will be seen to undergo a momentary deflection, as if produced by a wave of electricity passing in the same direction as the main current. After the needle has come to a state of rest, if the contact be renewed, a similar impulse will be communicated to it, but in a contrary direction. While the current continues, the needle returns to its state of rest, again to be deflected in the first direction by stopping the current. The same effects are produced, when the current being uninterrupted, the conducting wire is made suddenly to approach or recede from, the wire of the galvanometer. As the wires approximate, there will be a momentary current induced in the direction, contrary to the inducing current; and as the wires recede, an induced current in the same direction, as the inducing current. Motion may

* Prof. HENRY, of Princeton, was the first to construct magnets of this nature, which were possessed of great power.

by these modes be accumulated to a considerable amount in the needle, by making and breaking the contacts with the battery, in correspondence with the swing of the needle.

The sudden induction and cessation of the same magnetic force, in soft iron, either by the agency of a voltaic current, or by that of a common magnet, produces the same results. A combination of several helices upon a hollow cylinder of pasteboard, whose wires are connected end to end, and finally with the galvanometer, associated with an equal number which are connected similarly with the voltaic battery, produces a slight effect only by making and breaking contact. But when a soft iron cylinder, $\frac{7}{8}$ ths of an inch thick and 12 inches long, is introduced into the pasteboard tube, surrounded by the helices, the induced current affects the galvanometer powerfully. If the iron cylinder be replaced by one of copper, no effect beyond that of the helices alone, is produced.

Similar effects are produced by ordinary magnets. If the hollow helix be connected with the galvanometer, and the soft iron cylinder be introduced within its axis, a couple of bar-magnets being arranged with their opposite poles in contact, so as to resemble a horse-shoe magnet, and contact be then made between the other poles and the ends of the iron cylinder, whereby it is converted for the time into a magnet; on breaking the magnetic contacts, or reversing them, the magnetism of the iron cylinder is destroyed or reversed, at pleasure. When the contact takes place, the needle is deflected; continuing the contact, the needle becomes indifferent, resuming its first position; and on breaking contact, it is again deflected, but in the opposite direction to the first effect, and finally it again becomes indifferent. When the magnetic contacts are reversed, the deflections are reversed. "The actual contact of the magnets with the soft iron is not essential to the success of these experiments, for their near approximation induces sufficient magnetism in the cylinder, to generate the electric current which affects the needle. The first rise of the magnetic force induces the electric wave in one direction; its sudden decline, in the opposite."

By means of several ingenious machines for exalting the effects of magneto-electricity,* all the well known effects of voltaic currents may be produced, such as shocks, sparks, decompositions, &c.

Animal Electricity. The torpedo and gymnotus.

ORGANIC CHEMISTRY.

General constitution of organized bodies.

Chemical principles of organized bodies are all compounds, consisting of two, three, four or more simple bodies united together.

Hydrogen, carbon, oxygen and nitrogen, are the essential elements, or form the basis, of animal and vegetable beings.

Organic principles composed of two elements, consist of hydrogen and carbon (like oil of turpentine), of hydrogen and oxygen (water), of carbon and oxygen (oxalic acid), or of carbon and nitrogen (cyanogen). Organic principles of the three elements, carbon, hydrogen, and oxygen (most vegetable acids, sugar, alcohol, grain, &c.), are the most abundant. A few organized bodies are composed of carbon, hydrogen and nitrogen, (azulmic acid); while the carbazotic acid is supposed to be composed of carbon, nitrogen, and oxygen. The vegetable alkalis are examples of bodies, consisting of the four organic elements, above mentioned.

Vegetable Chemistry.

Vegetable principles arranged under four groups, viz. 1, acids; 2, alkalies; 3, intermediate principles; 4, neutral principles.

VEGETABLE ACIDS. Divisible into volatile, fixed, oily, acids containing nitrogen, and compound acids.

Table of Volatile Acids.

Name.	Constituents.	
Oxalic,	$C^2 O^3$	Crystallizes in slender 4 and 6 sided prisms, with 3 equiv. of water: very sour: soluble in 15 of water. At 330° the acid sublimes with 1 eq. of water.

* Saxton's magneto-electric machine, Page's double helix and electrotome, and Page's separable helix and revolving armature.

Croconic,	$C^5 O^4$	{ Formed in the process for potassium, from the ignition of cream of tartar in iron bottles. A lemon-yellow powder: very soluble: very sour.
Formic,	$C^2 H O^3$	{ From ants; also from the reaction of tartaric and sulphuric acids mingled with binox. mang. A strong acid liquid, sp. gr. = 1.116: contains 19.6 p. c. water.
Mellitic,	$C^4 H O^3$	{ From the mellate of alumina (honey-stone). In needle-shaped crystals; very sour. When sublimed, gives rise to pyromellitic acid.
Succinic,	$C^4 H^2 O^3$	{ From amber. Foliated crystals. Soluble in 24 water: acid.
Acetic,	$C^4 H^3 O^3$	{ Before distillation, called vinegar. A liquid consisting of 1 eq. acid + 1 of water: sp. gr. = 1.062: crystallizes at 45°. Does not decompose carb. lime, unless diluted. Evaporates rapidly.
Lactic,	$C^6 H^4 O^4$	{ From sour whey and from beet-root juice. A syrupy liquid without smell: very sour.
Suberic,	$C^8 H^6 O^3$	{ From cork. In needle-like crystals. Melts at 130. Not very soluble.
Naphthalic,	$C^{10} H^2 O^4$	{ Feathery crystals, resembling benzoic acid: little soluble.
Sebacic,	$C^{10} H^8 O^3$	
Camphoric,	$C^{10} H^7 O^3$	{ From camphor. In white crystals: little soluble: taste slightly acid.
Valerianic,	$C^{10} H^9 O^3$	{ From valeriana: oily liquid: sp. gr. = 0.94: very sour.
Benzoic,	$C^{14} H^5 O^3$	{ Needle-form crystals: melts at 248° and sublimes at 473°. When pure, no smell.
Cinnamonic,	$C^{18} H^7 O^3$	{ From cinnamon. Colorless crystals; smells at 248°; distills at 559°, its vapor having a strong odor.
Esculic,	$C^{52} H^{46} O^{24}$	From horse-chestnuts.

Oxalates.

Oxalates of potassa. Of these, there are three. The neutral oxalate crystallizes in oblique rhombic prisms, and contains 1 eq.

of water. Soluble in 2 of water, at 60° . It is used as a test for lime. The binoxalate is contained in the juice of sorrel. It crystallizes in rhomboids, and contains 2 eq. of water. It is less soluble than the neutral oxalate. It is used for removing stains from linen, and is sometimes called the essential salt of lemons. The quadroxalate crystals contain 7 eq. of water, and is the least soluble of the three.

Oxalates of soda. A neutral and a binoxalate are known.

Oxalate of ammonia. In acicular crystals, which contain 2 eq. of water. Very soluble in water. It is used as a test for lime.

Oxalate of lime. This oxalate has been detected in the mineral kingdom. As prepared by the chemist is a white powder, and is insoluble in water. It is the basis of the mulberry calculus.

Acetates.

Acetate of potassa. The crystals contain 2 eq. of water. It is very soluble. The pharmaceutic preparation is made by heating the crystals to fusion, whereby the water and a part of the acid are expelled, the residuum having an alkaline reaction.

Acetate of soda. Its crystals contain 6 eq. of water. It is not deliquescent. It becomes anhydrous at 550° ; and suffers decomposition at 600° . Used in the preparation of strong acetic acid.

Acetate of ammonia. Called the spirit of mindererus, and used as a febrifuge.

Acetate of baryta. Used as a test for sulphuric acid.

Acetate of alumina. Used by dyers and calico-printers as a basis, or mordant.

Acetates of lead. The neutral acetate (*saccharum saturni*). In rounded prisms, whose primary form is a right rhombic prism. They contain 3 equivalents of water; effloresce slightly; dissolve in 4 of water. Solution has a sweetish and astringent taste. The solution suffers partial decomposition from the carbonic acid of the air. It is used both as a sedative and astringent. The triacetate (consisting of 1 eq. acid + 3 protox. lead) is called the subacetate of lead, as well as *extractum saturni*: it is prepared by boiling 1 part of the neutral acetate, with 2 of freshly ignited litharge in 25 of water.

Acetates of copper. The neutral acetate crystallizes in octahedrons with a rhombic base. They contain 1 eq. of water. Soluble in 20 of water.

The dinacetate is formed, when copper plates are covered with a layer of the neutral acetate, made into a thin paste with water, and exposed for two months to a moist atmosphere. It forms crystalline, blue scales and silky needles: and contains 6 equivalents of water. It is the chief ingredient of the blue varieties of the pigment, verdigris. When freely mixed with water, it is decomposed into the neutral acetate, and an insoluble triacetate. Another sub-salt, composed of 3 equivalents of oxide, 2 of acid and 6 of water, is supposed to be the principal ingredient of the green varieties of verdigris.

Fixed acids.

When the requisite care is observed in heating many of these, they give rise to new acids, the names and composition of which are given in the following table.

Table 1st of Fixed Acids.

Acids.	Composition.	Derivative acids.	Composition.
1. Malic,	$C^4 H^2 O^4$	1. Maleic or equisetic, 2. Paramaleic or fumaric,	$C^4 H O^3$
2. Citric,	$C^4 H^2 O^4$	3. Pyrocitric, } 4. Citricic, }	$C^5 H^2 O^3$
3. Tartaric,	$C^4 H^2 O^5$	5. Pyrotartaric, 6. Pyruvic,	$C^5 H^3 O^3$ $C^6 H^3 O^5$
4. Racemic,	do.	yields similar acids.	
5. Mucic,	$C^6 H^4 O^7$	7. Paramucic, 8. Pyromucic,	$C^6 H^4 O^7$ $C^{10} H^3 O^5$
6. Meconic,	$C^7 H^2 O^7$	9. Pyromeconic, 10. Metameconic,	$C^{10} H^3 O^5$ $C^{12} H^4 O^{10}$
7. Gallic,	$C^7 H^3 O^5$	11. Pyrogallic, 12. Metagallic,	$C^6 H^3 O^3$ $C^{12} H^3 O^3$
8. Kinic,	$C^{15} H^9 O^9$	13. Pyrokinic.	

1. Malic acid is contained in grapes, currants, gooseberries, and most acidulous fruits, being frequently associated with tartaric and citric acids. It is strongly acid, crystallizes with difficulty, and is very soluble in water and alcohol. 2. Citric acid is obtained from the juice of the lime and lemon, being separated from

associated principles by the addition of chalk, whereby the insoluble citrate of lime is formed, which after being well washed, is decomposed by dilute sulphuric acid. Citric acid crystallizes in large rhombic prisms, containing 1 equivalent of water. In a dry state, they may be preserved for any length of time. Soluble in an equal weight of water. Employed in calico-printing, and for medicinal and domestic purposes, instead of lemon-juice. 3. Tartaric acid is found in most acidulous fruit, in combination with lime or potassa. It is obtained by boiling cream of tartar and chalk (mixed in the ratio of 189.1 to 50.8) in water. The insoluble tartrate of lime is decomposed by dilute sulphuric acid, as in the case of citric acid. Tartaric acid crystallizes in thin, prismatic crystals, which contain 1 equivalent of water. Soluble in 6 of water: the solution possesses an agreeably acid flavor. 4. Racemic acid is associated with tartaric acid in the grape. It was at one time called the vinic acid. 5. Mucic (saccholactic acid) is obtained from gum, manna, and sugar of milk, by the action of nitric acid. It is a weak acid, and requires 60 of water for solution. 6. Meconic acid is obtained from the juice of the poppy, in which it exists in combination with morphina. 7. Gallic acid exists in the bark of many trees, in gall-nuts, and in most substances which contain tannic acid. When pure, it has a weak acid taste, accompanied with slight astringency. The crystals are colorless needles, and require 100 of water for solution. With persulphate of iron, it produces a deeper blue ink than tannic acid. It occasions no precipitates in solutions of the vegetable alkalies. 8. Kinic acid exists in cinchona bark in combination with lime, quinina and cinchonina. It is a strong acid, and is soluble in $2\frac{1}{2}$ of water.

Malates.—The malates of soda and potassa are deliquescent. The bi-malate of ammonia crystallizes very readily. The most insoluble of the order are baryta, lime, and the oxides of lead and silver; but these, excepting the malate of baryta, are soluble in hot water.

Citrates.—The citrates of potassa, soda, ammonia, magnesia, and oxides of iron, are soluble in water; while those of lime, baryta, strontita, and the oxides of lead, mercury, and silver, are sparingly so in hot water, unless a large excess of acid is present.

Tartrates.

Tartrates of potassa. The neutral tartrate (soluble tartar), formed by neutralizing a solution of the bitartrate of potassa with carbonate of potassa, presents itself in irregular six sided prisms, with dihedral summits. Deliquescent: very soluble in water. The crystals contain 2 equivalents of water, and become anhydrous at 248° . The bitartrate, as obtained in an impure state, incrusting the side of wine casks, is called tartar. When purified, it is called the cream of tartar. Requires 60 of cold and 14 of boiling water, for solution. Crystals, irregular, six sided prisms, having 1 equivalent of water. Taste, acid. It is used in the formation of the tartaric acid, and all the tartrates: also for obtaining pure carbonate of potassa, into which it is converted, by ignition. When deflagrated with half its weight of nitre, it forms black flux. Tartrate of potassa and soda (Rochelle salt) is prepared by neutralizing bitartrate of potassa with carbonate of soda. Crystals derived from a rhombic prism. They contain 8 equivalents of water; and are soluble in 5 of water. Tartrate of soda is formed in the preparation of the common effervescing draught, made by dissolving equal weights of tartaric acid and the bicarbonate of soda. Tartrate of antimony and potassa (tartar emetic) is prepared by boiling sesquioxide of antimony, with a solution of bitartrate of potassa. When first formed, it presents transparent crystals, which become opaque on exposure to the air. They contain 2 equivalents of water. Soluble in 15 of water at 60° , and in 3, at 212° . Taste, styptic. The solution undergoes decomposition by keeping.*

Gallates.

Gallates of iron. The gallate of the protoxide of iron is formed with difficulty; but if gallic acid be added to a solution of the sesquisulphate of iron, a dark, blue precipitate of gallate of sesquioxide of iron falls, which is slowly dissolved. This gallate enters into the constitution of common writing ink.

* It is decomposed by lime-water, the alkaline carbonates, the mineral acids, and some of the metallic salts. The decoctions of yellow cinchona bark, of gall-nuts, and of all the vegetable astringents, precipitate the antimony in the condition of a tannate of the sesquioxide of antimony. Hydrosulphuric acid throws down the orange, sesquisulphuret of antimony.

Table 2d of Fixed Acids.

9. Ellagic,	$C^7 H^2 O^4$	{ From nutgalls. The name from the French word <i>galle</i> , inverted.
10. Cahincic,	$C^7 H^6 O^{3\frac{1}{2}}$	{ From Kahinca bark.
Bicoloric,	$C^8 H^{4\frac{1}{2}} O^5$	{ From horse-chestnut bark, and various plants.
11. Caffaic,	$C^{12} H^{17} O^{19}$	{ From coffee. A white, insoluble powder.
Picrotoxic,	$C^{12} H^7 O^5$	{ From the <i>Cocculus Indicus</i> .
12. Japonic,	$C^{12} H^4 O^4$	{ From catechuic acid, acted upon by potassa.
13. Mechloric,	$C^{14} H^7 O^{10}$	{ From meconin, acted upon by chlorine.
14. Catechuic,	$C^{15} H^5 O^5$	{ From catechu.
15. Amygdalic,	$C^{40} H^{26} O^{24}$	{ From the bitter almond.
16. Tannic,	$C^{18} H^3 O^{12}$	{ In the bark of most trees, in astringent plants generally, but purest in nut-galls.* Taste, astringent. Very soluble in water. It becomes gallic acid, by decomposition.
17. Rubinic,	$C^{18} H^6 O^9$	{ From catechuic acid, acted upon by carbonate of potassa.
18. Ulmic,	$C^{30} H^{15} O^{15}$	{ From decomposed wood and from peat.

Tannates.—The basis of common writing ink is the sesquitantrate of the sesquioxide of iron.

Oily acids.—They are thus named because they are formed from oils or fats, and enter into the composition of soaps; or because, they have many of the characters of oils.†

Table of Oily Acids.

1. Butyric,	$C^8 H^5 O^3$	From butter.
2. Smilacic,	$C^8 H^{7\frac{1}{2}} O^3$	From sarsaparilla.
3. Phocenic,	$C^{10} H^{7\frac{1}{2}} O^3$	From porpoise oil.
4. Hydrospiroilic,	$C^{12} H^6 O^4$	From <i>Spiræa ulmifolia</i> .

* Nut-galls afford about 20 p. c. of tannic acid.

† From the analogy of animal and vegetable oily acids, they are here described together.

- | | | |
|-----------------------------|----------------------|--|
| 5. Caproic, | $C^{12}H^{10}O^3$ | { From the butter of goat's milk. |
| 6. Spiroilic, | $C^{12}H^5O^3$ | |
| 7. Chlorophenisisic, | $C^{12}H^3O^2$ | { From coal-tar. |
| 8. Chlorophenescic, | $C^{12}H^3O^2$ | |
| 9. Œnanthic, | $C^{14}H^{13}O^2$ | From œnanthic ether. |
| 10. Anchusic, | $C^{17}H^{10}O^4$ | From the Anchusa tinctoria. |
| 11. Rocellic, | $C^{17}H^{16}O^4$ | From the Rocella tinctoria. |
| 12. Capric, | $C^{18}H^{14}O^3$ | { From the butter of the cow and goat. |
| 13. Ricinic, | $C^{24}H^{24}O^4$ | |
| 14. Santonic, | $C^{60}H^{36}O^{12}$ | { From seed of Artemesia santonica (southern wood). |
| 15. Stearic, | $C^{72}H^{68}O^4$ | |
| 16. Oleic, | $C^{70}H^{62}O^7$ | { From soaps made with vegetable oils. Insoluble in water. |
| 17. Metoleic, | $C^{70}H^{64}O^9$ | |
| 18. Hydroleic, | $C^{70}H^{65}O^{10}$ | { From the spontaneous decomposition of sulpho-oleic acid at 212°. |
| 19. Margarinic, | $C^{70}H^{69}O^8$ | |
| 20. Metamargaric, | $C^{70}H^{67}O^6$ | { From soaps made with fixed oils. Color, white. Lustre, pearly. Insoluble in water. |
| 21. Hydromargaric, | $C^{70}H^{70}O^9$ | |
| 22. 23. Hircic and Elaidic. | Not yet analyzed. | |

Acids containing nitrogen.

- | | | |
|-----------------|--|---|
| 1. Azulmic, | $C^3H^4N^1O^4$ | { From the decomposition of alcoholic solution of cyanogen. |
| 2. Indigotic, | $C^{23}H^{7\frac{1}{2}}N^{1\frac{1}{2}}O^{15}$ | |
| 3. Carbazotic, | $C^{15}N^3O^{15}$ | { From indigo acted upon by nitric acid. |
| 4. Aspartic, | $C^3H^5N^1O^6$ | |
| 5. Cholesteric, | $C^{13}H^{10}N^{\frac{1}{2}}O^6$ | From cholesterine. |
| 6. Ambreic, | $C^{57}H^{47}N^4O^{27}$ | From ambreine. |

- | | | |
|--------------------|-----------------|---|
| 7. Nitrosaccharic, | } Not analyzed. | { From gelatine, acted upon by sulphuric acid.
From beef muscle, acted upon by sulphuric acid. |
| 8. Nitroleucic, | | |

Acids imperfectly examined.

1. Pectic acid. A transparent and colorless jelly; obtained from the juice of currants, gooseberries, cherries, apples, and many other fruits, as well as from the roots of carrots, turnips, parsnips, and from the inner bark of most trees.

2. Crenic acid. This acid, together with the apocrenic, were first discovered by BERZELIUS, in a certain mineral water in Sweden; where they were associated with sesquioxide of iron and other principles, forming a compound which had before, passed under the name of extractive matter. Crenic acid has a yellow color, a sharp acid and astringent taste. Crenate of protoxide of iron is soluble in water. By exposure to the air, it becomes an insoluble, crenated peroxide of iron.

3. Apocrenic acid has a brown color, and resembles vegetable extract. It is slightly soluble in water, but dissolves readily in crenic acid. The apocrenate of iron is soluble in water; but on exposure to the air, it passes to the state of a sub-apocrenated peroxide, and falls in black flocks.

4. Puteanic acid. Found with the two foregoing acids in ochre.

5. Palmic acid. An acid from castor-oil.

6. Gummic acid. From gum-senegal.

7. Igasuric, or strychnic acid. Found in several species of the Strychnos.

8. Vulpinic acid. From the Lichen vulpinus.

9. Lactucic acid. From the juice of the Lactuca virosa.

10. Verdous and verdic acids. Acids from various families of plants. The verdous acid is colorless, but becomes green on exposure to the air.

11. Rheic acid (rhein). From the rhubarb.

12. Polygalic acid. From Polygala senega.

13. Cornic acid. From the Cornus Florida.

14. Gentisic acid (gentisin). From the the Gentiana lutea.

15. Ampelic acid. From a species of naphtha obtained from the distillation of bituminous slate.

16. Fungic acid. From several species of the mushroom family.

17. Laccic acid. From stick-lac.

18. Solanic acid. In the fruit of the different species of Solanum.

19. Krameric acid. From the *Krameria triandra*.

20. Boletic acid. From the juice of the *Boletus pseudo-ignarius*.

21. Cevaetic acid. From the seeds of the *Veratrum veradilla*.

Compound acids. These consist of a vegetable principle, united to a strong mineral or vegetable acid. They have been divided into two sets. The first consist of two atoms of an acid, combined with one atom of a base, which may be driven off by a stronger base. They may be regarded as acidulous, or super-salts. The second set contain hyposulphuric acid combined with an organic substance, not acting the part of a base, and not capable of being expelled by a stronger base.

Table of the first set.

1. Althionic (sulphovinic),	$2(\text{SO}^3) + \text{C}^1\text{H}^5\text{O} + \text{HO}$
2. Oxalovinic,	$2(\text{C}^2\text{O}^3) + \text{C}^1\text{H}^5\text{O} + \text{HO}$
3. Tartrovinic,	$2(\text{C}^4\text{H}^2\text{O}^5) + \text{C}^1\text{H}^5\text{O} + \text{HO}$
4. Racemovinic,	$2(\text{C}^4\text{H}^2\text{O}^5) + \text{C}^1\text{H}^5\text{O} + \text{HO}$
5. Sulphomethylic,	$2(\text{SO}^3) + \text{C}^2\text{H}^3\text{O} + \text{HO}?$
6. Tartromethylic,	$2(\text{C}^4\text{H}^2\text{O}^5) + \text{C}^2\text{H}^3\text{O}$
7. Racemomethylic,	$2(\text{C}^4\text{H}^2\text{O}^5) + \text{C}^2\text{H}^3\text{O} + \text{HO}$
8. Phosphovinic,	$2(\text{PhO}^{2\frac{1}{2}}) + \text{C}^1\text{H}^5\text{O}$
9. Arseniovinic,	$2(\text{AsO}^{2\frac{1}{2}}) + 2(\text{C}^4\text{H}^5\text{O})$
10. Camphovinic,	$2(\text{C}^{10}\text{H}^{7\frac{1}{2}}\text{O}^5) + \text{C}^1\text{H}^5\text{O} + \text{HO}$

Table of the second set.

1. Ethionic,	$\text{S}^2\text{O}^5 + \text{C}^1\text{H}^4\text{O} + \text{HO}$
2. Sulphonaphthalic,	$\text{S}^2\text{O}^5 + \text{C}^{20}\text{H}^7$
3. Hyposulphonaphthalic,	$2(\text{SO}^3) + \text{C}^{11}\text{H}^{15}$
4. Benzosulphuric,	$\text{S}^2\text{O}^5 + (\text{C}^{14}\text{H}^4\text{O}^2)$
5. Sulphocetic,	$\text{S}^2\text{O}^5? + (\text{C}^6\text{H}^{32}) + 2(\text{HO})$
6. Sulphoglyceric,	$\text{S}^2\text{O}^5? + (\text{C}^6\text{H}^{70})$
7. Sulphoindigotic and hyposulphoindigotic.	

8. Stearin, $\overset{\text{Stearic acid.}}{2(\text{C}^{14} \text{H}^{34} \text{O}^{10})} + \overset{\text{Glycerin.}}{\text{C}^6 \text{H}^7 \text{O}^5} + 2(\text{HO})$
9. Olein, $\overset{\text{Oleic acid.}}{2(\text{C}^{35} \text{H}^{30} \text{O}^{2\frac{1}{2}})} + \text{C}^6 \text{H}^7 \text{O}^5 + 2(\text{HO})$
10. Vegetosulphuric.
11. Hyponitromeconic, $\frac{1}{2}(\text{NO}^4) + \text{C}^{10} \text{H}^5 \text{O}^4$
12. Xanthic, $2(\text{CS}^2) + \text{C}^4 \text{H}^5 \text{O} + \text{HO}$
13. Hydrocarbosulphuric, $\text{CS}^2 + \text{HS}$

VEGETABLE ALKALIES. Their present number is about 37, but only 31 of them have been sufficiently investigated, to leave no doubt concerning their alkalinity. The following is a process invented by M. O. HENRY, for their separation from the principles along with which they are commonly associated. It is founded on the fact that all the vegetable alkalies are precipitated by tannic acid, or infusions of nut-galls, but not by gallic acid:—Digest the plant containing the alkali in warm water, acidulated with sulphuric acid. Draw off the clear liquid, neutralize it by potassa; and add a concentrated infusion of nut-galls as long as a precipitate falls. Separate the precipitate, wash it with cold water, and mix it intimately with a slight excess of slacked lime. Dry the mixture over the vapor-bath, till it is reduced to powder. Digest the powder in alcohol or ether. Filter, distil off the alcohol or ether. Set the residue aside for some days. The alkali will be deposited in crystals.

Table of alkalies which have been analyzed.

1. Menispermina,	.	.	.	$\text{C}^{13} \text{H}^{12} \text{N O}^2$
2. Cinchonina,	.	.	.	$\text{C}^{20} \text{H}^{12} \text{N O}^{1\frac{1}{2}}$
3. Quinina,	.	.	.	$\text{C}^{20} \text{H}^{12} \text{N O}^2$
4. Arecina,	.	.	.	$\text{C}^{20} \text{H}^{12} \text{N O}^3$
5. Salicin,*	.	.	.	$\text{C}^4 \text{H}^3 \text{O}^2$
6. Sabadillina,	.	.	.	$\text{C}^{20} \text{H}^3 \text{N O}^5$
7. Thebaina,	.	.	.	$\text{C}^{25} \text{H}^{14} \text{N O}^4$
8. Delphina,	.	.	.	$\text{C}^{27} \text{H}^{18} \text{N O}^{2\frac{1}{2}}$
9. Narceina,	.	.	.	$\text{C}^{28} \text{H}^{20} \text{N O}^{12}$
10. Codeina,	.	.	.	$\text{C}^{32} \text{H}^{19} \text{N O}^5$
11. Strychnina,	.	.	.	$\text{C}^{30} \text{H}^{16} \text{N O}^4$

* A neutral substance.

12. Brucina,	. . . . .	$C^{32} H^{18} N O^7$
13. Veratrina,	. . . . .	$C^{34} H^{32} N O^6$
14. Emetina,	. . . . .	$C^{35} H^{25} N O^9$
15. Solanina,	. . . . .	$C^{28} H^{21} N^{\frac{1}{2}} O^{3\frac{1}{2}}$
16. Narcotina,	. . . . .	$C^{40} H^{26} N O^{12}$
17. Morphina,	. . . . .	$C^{34} H^{18} N O^6$
18. Atropina,	. . . . .	$C^{22} H^{15} N O^3$
19. Conicina,	. . . . .	$C^{12} H^{14} N O$
20. Parillina,	. . . . .	$C^9 H^8 O^3$
21. Meconin,*	. . . . .	$C^{10} H^5 O^1$

Menispermia, derived from the fruit of the *Menispermum cocculus*.

Cinchonina, derived from the grey Peruvian bark; crystallizes in delicate, hair-like tufts, and requires 2500 of water for solution. Its taste is bitter. It is very soluble in alcohol. It combines in two proportions with acids, forming neutral salts and disalts; their solution in water has a very bitter taste. The disulphate of cinchonina is formed, by saturating sulphuric acid with the alkali. The salt crystallizes in short oblique prisms, terminated by dihedrals. It is soluble in 54 of water. When sulphuric acid is added to the solution, and the liquid evaporated, octahedral crystals of the neutral sulphate are thrown down, which are soluble in about half their weight of water, at 55°.

Quinina is extracted from yellow bark, and is crystallized with difficulty. The crystals contain water, which they give up, when heated to 302°. Its taste is more bitter than cinchonina. It is soluble in 200 of boiling water. Its salts are remarkable for a strong, bitter taste. They are mostly soluble in water. There are two sulphates of quinina, the disulphate and the neutral sulphate, of which the former is the one so much employed as a febrifuge in medicine.† It contains 2 eq. of water, and effloresces when exposed to the air: is soluble in 740 of water at 55°, and in 30 at 212°. It dissolves in 80 of alcohol (sp. gr. 0·85), at 60°. It crystallizes in tufts, which are slightly flexible and possessed of a pearly lustre. When heated they melt, and assume

* A neutral substance.

† The annual manufacture of this salt in Paris is 120,000 oz.

the appearance of wax. At a higher temperature, they assume a fine, red color, and at last are dissipated, without residue. The neutral sulphate may be formed, by adding a little sulphuric acid to the solution of the disulphate, and crystallizing the solution.

Aricina was obtained from a parcel of bark from Arica, in Peru, which had been adulterated with some unknown vegetables.

Salicin, obtained from the bark of certain species of the genus *Salix*.

Veratrina, from the seeds of the *Veratrum album*, or white hellebore. It has the appearance of a yellowish resin. It is insoluble in water and ether, but is taken up by alcohol. It is fusible, at 240° . Its taste is excessively acrid. A few grains of it taken internally, occasion death.

Sabadillina, an alkaloid, associated with veratrina in the white hellebore.

Thebaina, from opium, but is supposed by THOMSON to be evolved from morphina, in consequence of the action of lime, used in the process for obtaining it.

Delphina, from the *Delphinium staphysagria*.

Narceina is obtained from opium. Its crystals have a white color and silky lustre. Taste slightly bitter: dissolves in 375 of water at 57° , and in 230 at 212° .

Codeina is also an ingredient of opium. It is obtained in silky tufts of a white color, which require 100 of water for solution. When administered in doses from 4 to 6 grs. (according to Dr. WM. GREGORY), it produces an excitement similar to intoxication. It loses much of its activity, when combined with acids.

Strychnina exists in the fruit of several species of *Strychnos*, particularly in the *S. nux-vomica*. It is also found in the poisonous matter called upas, with which the natives of some parts of India, poison their arrows. When obtained from a pure alcoholic solution, it presents itself in 4 sided prisms, surmounted by 4 sided pyramids. It is destitute of smell, and is intensely bitter; it operates as one of the most virulent poisons known, occasioning violent muscular contractions and tetanus. It is sometimes administered in paralysis, in doses of $\frac{1}{16}$ th grain; but more frequently, combined with acetic acid. The salts of strychnina are all soluble in water, and possessed of an intensely bitter taste.

Brucina exists in the bark of the *Brucea antidysenterica*, and also along with strychnina in *nux-vomica*. Its crystals require 850 of cold water, for solution. Its taste is intensely bitter; and its effects upon the animal economy are similar to those of strychnina, but less violent.

Emetina is the active ingredient of *ipecacuanha*. It is a white, nearly insoluble powder. It acts very powerfully as an emetic, $\frac{1}{10}$ of a grain having been found an adequate dose.

Morphina is an abundant alkaline principle in opium, which affords it in the ratio of $\frac{1}{16}$ th its weight. It crystallizes in small, four sided prisms. It is insoluble in cold water; but dissolves in 40 of alcohol. When taken in the solid state, it is found to be nearly inert. It combines with the sulphuric, hydrochloric, acetic, and citric acids, forming soluble salts, all of which are used as therapeutic agents, particularly the hydrochlorate and acetate. The hydrochlorate of morphina (muriate of morphina) crystallizes in feathery crystals, which are soluble in 15 or 20 of water. The acetate is liable to lose a portion of its acid, when kept in the state of crystals.

Atropina, from the leaves of the *Atropa belladonna*, or deadly nightshade. It is a white, shining, saline body; crystallized in needle-formed prisms; inodorous, insipid, nearly insoluble in water, but very soluble in heated alcohol. It is supposed to exert a direct, sedative influence, unattended by the stimulating effect of the extract of belladonna.

Conicina, the active principle of *Conium maculatum*, or hemlock. It has the appearance of a yellowish, liquid oil. It is lighter than water, and slightly soluble in it; but dissolves completely in alcohol and ether. Smell strong and penetrating: taste acrid and corrosive,—occasioning death with nearly the same rapidity as prussic acid. It forms salts with the sulphuric, phosphoric, nitric and oxalic acids, which crystallize in forms of considerable size.

Parillina, found in the root of *Smilax sarsaparilla*, or the common sarsaparilla.

Meconin, a neutral substance, obtained from opium, in which it exists, in the proportion of $\frac{1}{360}$ th its weight. It does not possess alkaline properties; and seems incapable of combining with the acids in definite proportions.

Table of imperfectly examined alkalies.

1. Jervina. Extracted from the roots of the *Veratrum album*.
2. Digitalina. From the dried leaves of *Digitalis purpurea* (foxglove).
3. Nicotina. From the leaves and seeds of the different species of *Nicotiana* (tobacco). It is obtained in transparent, white crystals; they rapidly absorb water and form a colorless liquid, which retains the liquid state, at 21° . At 212° , it gives out a white smoke (which has an alkaline reaction): at 375° it boils, at the same time suffering decomposition. Its taste is acrid and caustic. Soluble in water, in all proportions. It is a most virulent poison, a single drop being sufficient to kill a moderately sized dog.
4. Curarina. Found in a substance used by the South American Indians for poisoning arrow-heads, and called by them curara, or urari.
5. Corydalina. Found in the root of the *Corydalis tuberosa*, or *Fumaria bulbosa*.
6. Jamacina. Found in the bark of the cabbage-bark tree, the *Geoffroya Jamaicensis* and the *G. inermis*.
7. Surinamina. Found in the bark of *Geoffroya Surinamensis*.
8. Cathartina. In the leaves of the *Cassia acutifolia*. It possesses the purgative qualities of senna in great perfection.
9. Guaranina. From the Guarana, a Brazilian medicine, obtained from the fruit of the *Paullinia sorbilis*.
10. Hurina. From a tree in Bogota called Ajuapar, and supposed to be the *Hura crepitans*.
11. Sanguinarina. Obtained from the root of the *Sanguinaria canadensis*. Its taste is bitter: it is insoluble in water, but dissolves in alcohol and ether.
12. Violina. From the *Viola odorata*.
13. Esenbekina. From the *Esenbekia febrifuga*.
14. Buxina. From the *Buxus sempervirens*, or the box-tree.
15. Eupatorina. From the *Eupatorium cannabinum*.
16. Crystallina. From indigo.
17. Theina. From tea.

INTERMEDIATE BODIES.

Under this head are included those vegetable principles, which seem capable of entering into combination with other bodies; although it is not yet settled, whether they are to be considered as acid or alkaline. They may be treated of, under the following heads: 1, alcohol and its compounds; 2, ethers; 3, pyroxylic spirit; 4, coloring matters; 5, fixed oils; 6, volatile oils; 7, resins; 8, gum-resins.

1. *Alcohol and its compounds.*

Alcohol is the product of the vinous fermentation. When perfectly anhydrous, or in the condition of absolute alcohol, its sp. gr. = 0.796 at 60°. It unites with water in every proportion, the union being attended with a diminution of volume. Equal weights of alcohol and water form proof-spirit, whose sp. gr. = 0.917.* Alcohol has long been regarded as formed of

	Sp. gravity.
1 volume olefiant gas, . . .	0.9722
1 " vapor of water . . .	0.6250
	<hr/> 1.5972

condensed into 1 volume; so that its sp. gr. = 1.5972, when in a state of vapor: but according to LIEBIG, it is an hydrate of ether,—the composition of ether being $C^4H^5 + O$, that of alcohol is thus stated, $(C^4H^5O) + HO$.

Aldehyde.† A colorless liquid; sp. gr. = 0.79: boils at $79\frac{1}{4}^\circ$: has a peculiar, ethereal and penetrating odor. When breathed, produces a cramp in the stomach. It burns like alcohol.

Compounds of aldehyden. LIEBIG supposes that there exists an unknown base composed of C^4H^3 , of which aldehyde is an hydrated oxide.

Aldehyden is C^4H^3 .

Aldehyde is $C^4H^3O + HO$.

Bromide of aldehyden, $C^4H^3 + Br$. A colorless volatile liquid.

* According to the researches of BRANDE, brandy, rum, gin and whiskey, contain from 51 to 54 p. c. of alcohol; the stronger wines from 18 to 25 p. c., while in claret, Sauterne, Burgundy, Hock and Champagne, the proportion varies from 12 to 17; and in cider, ale and porter, from 4 to 10 p. c.

† Derived from alcohol dehydratus.

Iodide of aldehyden, $C^4H^3 + I$.

Chloroform. Formed by distilling a mixture of alcohol, and the aqueous solution of chloride of lime. It is a colorless liquid; sp. gr. = 1.48. It boils at $141\frac{1}{2}^\circ$. Its composition is $C^2H + Cl^3$.

Bromoform, $C^2H Br^3$.

Iodoform, C^2HI^3 .

Chloral.* Formed by passing a current of dry chlorine through absolute alcohol. It is a clear oily liquid: sp. gr. = 1.50: boils at 201° . Odor pungent: taste like olive-oil: very soluble in water. Its constitution is thus expressed: $C^4HCl^3O^2$.

Bromal. Formed by pouring bromine into absolute alcohol.

Ethal.† Obtained from spermaceti. It is a solid colorless body, which melts at 118° . Insoluble in water; but taken up by alcohol. When heated in an open vessel, it burns like wax.

Ethers. LIEBIG has called the base of ether (C^4H^5) ethyl. It has not yet been obtained in a separate state; but several of its compounds with simple bodies have been examined, of which the following are the most important:—

1. *Ethers with a base of C^4H^5 .*

- | | |
|---|----------------|
| 1. Oxide of ethyl, or common ether, | C^4H^5O |
| 2. Chloride of ethyl, or muriatic ether, | C^4H^5Cl |
| 3. Bromide of ethyl, or hydrobromic ether, | C^4H^5Br |
| 4. Iodide of ethyl, or hydriodic ether, | C^4H^5I |
| 5. Sulphuret of ethyl, or mercaptan, | $C^4H^5S + HS$ |
| 6. Cyanodide of ethyl or hydrocyanic ether, | $C^4H^5(C^2N)$ |
| 7. Sulphohydric ether, | $C^4H^5(HS)?$ |

Common ether (sulphuric ether) is a colorless, limpid liquid, of a pungent taste and fragrant odor. Sp. gr. = 0.7. Boils at 96° . It combines with alcohol in every proportion. It dissolves the essential oils, resins, and most of the fatty principles. It is highly inflammable. Muriatic ether is a colorless liquid, of a penetrating; somewhat alliaceous odor, and a sweetish taste. It boils at 54° .

2. *Ethers with a base of C^4H^4 .*

1. Light oil of wine, . . . C^4H^4

* By joining together the two first syllables of chlorine and alcohol.

† By joining together the two first syllables of ether and alcohol.

2. Chloric ether, . . . $C^1H^4 + Cl^2$
3. Bromic ether, . . . $C^1H^4 + Br^2$
4. Iodic ether, . . . $C^1H^4 + I^2$
5. Acetal, . . . $C^1H^4 + H^{\frac{1}{2}}O$
6. Sulphocyanic ether.

Chloric ether is formed by several processes, and is possessed of a hot, sweetish ethereal flavor. It is soluble in alcohol in every proportion, forming an aromatic and saccharine fluid, very grateful to the taste. It has been employed to some extent in medicine, as a diffusible stimulant. The bromic and iodic ethers are compounds, strongly analogous to the chloric ether.

3. *Ethers consisting of sulphuric ether and an acid.*

1. Nitric ether, . . . $C^4H^5O + N \quad O^3$
2. Carbonic ether, . . . $C^4H^5O + C \quad O^2$
3. Oxalic ether, . . . $C^4H^5O + C^2 \quad O^3$
4. Formic ether, . . . $C^4H^5O + C^2 \quad H \quad O^3$
5. Succinic ether, . . . $C^4H^5O + C^4 \quad H^2 \quad O^3$
6. Acetic ether, . . . $C^4H^5O + C^4 \quad H^3 \quad O^3$
7. Benzoic ether, . . . $C^4H^5O + C^{14}H^5 \quad O^3$
8. Malic ether, . . . $C^4H^5O + C^4 \quad H^2 \quad O^4$
9. Citric ether, . . . $C^4H^5O + C^4 \quad H^2 \quad O^4$
10. Tartaric ether, . . . $C^4H^5O + C^4 \quad H^2 \quad O^5$
11. Mucic ether, . . . $C^4H^5O + C^6 \quad H^4 \quad O^7$
12. Pyrocitric ether, . . . $C^4H^5O + C^5 \quad H^2 \quad O^3$
13. Pyrotartaric ether, . . . $C^4H^5O + C^5 \quad H^3 \quad O^3$
14. Pyromucic, . . . $C^4H^5O + C^{10}H^3 \quad O^5$
15. Suberic, . . . $C^4H^5O + C^8 \quad H^6 \quad O^3$
16. CEnanthic, . . . $C^4H^5O + C^{14}H^{13}O^2$
17. Chlorocarbonic, . . . $C^4H^5O + C^2 \quad Cl \quad O^3$
18. Cyanic ether, . . . $C^4H^5O + 2(C^2NO) + 3(HO)$
19. Chlorocyanic ether, . . . $C^4H^5O + C^2 \quad NCl$
20. Elaidic ether, . . . $C^4H^5O + C^{35}H^{33}O^3$

In the foregoing group, the ether (C^4H^5O) possesses the character of a base, and neutralizes the acids with which it combines.

4. *Table of ethers, consisting of 1 atom of ether + 2 of an acid.*

1. Heavy oil of wine, $C^4H^4(H^{\frac{1}{2}}O^{\frac{1}{2}}) + SO^3$

2. Althionic acid, . . . $C^4H^4O + 2(SO^3) + HO$
3. Phosphovinic acid, . . . $C^4H^4O + 2(PhO^{2\frac{1}{2}})$
4. Oxalovinic acid, . . . $C^4H^5O + 2(C^2O^3) + HO$
5. Tartrovinic acid, . . . $C^4H^5O + 2(C^4H^2O^5) + HO$
6. Racemovinic acid, . . . $C^4H^5O + 2(C^4H^2O^5) + HO$
7. Camphovinic acid, . . . $C^4H^5O + 2(C^{10}H^{7\frac{1}{2}}O^5) + HO$

Pyroxylic spirit.—Obtained in the aqueous liquor, which comes off during the distillation of wood, in the process for acetic acid. It is rectified by repeated distillations, the last being made over quick-lime. It is a colorless fluid, whose sp. gr. = 0.798; it boils at 150° . Its odor is both aromatic and alcoholic. When its vapor is mixed with air and left in contact with spongy platinum, much heat is evolved, and formic acid is formed. When pyroxylic acid is distilled along with a solution of chloride of lime, chloroform is obtained. Pyroxylic spirit dissolves potassa, soda and baryta: also most salts and resins, like alcohol. It is acted upon by the acids, and a set of compounds is formed, very analogous to the ethers, which the same acids form with alcohol. The name of methylene has been given by MM. DUMAS and PELIGOT, to what they consider to be the base of pyroxylic acid, and which they make C^2H^2 , and pyroxylic spirit, $C^2H^2 + HO$; but Dr. THOMSON applies to these compounds LIEBIG's theory of ethers, whereby the base of pyroxylic spirit becomes C^2H^3 , and the spirit itself C^2H^3O . Some of the salts of methylene, analogous to the acid ethers, are the following:

Sulphate,	.	.	$C^2H^3O + SO^3$
Nitrate,	.	.	$C^2H^3O + NO^3$
Oxalate,	.	.	$C^2H^3O + C^2O^3$
Acetate,	.	.	$C^2H^3O + C^4H^3O^3$

COLORING MATTERS.

Blue coloring matters. 1. Indigo is obtained from the leaves of the Indigofera, a genus of leguminous plants found in India, Africa and America. It may also be obtained from the leaves of the Nerium tinctorium, as well as from the Isatis tinctoria (woad). Indigo, as it occurs in commerce, is impure, not having more than half its weight of blue coloring matter. When heated to 550° it sublimes, and gives rise to long, flat needles. Its vapor is transparent, and of a beautiful, reddish-violet color. Its melting and

decomposing point is but little above that, at which it is vaporized. The sp. gr. of sublimed indigo = 1.35. Indigo is destitute of taste and smell, and has neither the characters of an acid or base. It is insoluble in water, oils, ether and alcohol. But when it has been treated with something capable of abstracting oxygen, as protosulphate of iron, it assumes a yellowish white color, and has been called indigogen. It is more soluble in bases: and if the alkaline solution of indigogen be brought in contact with oxygen gas, that gas is absorbed and the indigo is regenerated. Indigo is dissolved in concentrated sulphuric acid, whereby it suffers a remarkable change, being converted into a blue pigment, different in its qualities from indigo. This blue substance (with which Saxon-blue is dyed) is called cerulin. Its mixture with the sulphuric acid is a semi-fluid, which requires much water for solution. The cerulin is precipitated by any salt of potassa, and has been called the ceruleo-sulphate of potassa.

2. Litmus or turnsole. Obtained from lichens, the *Lecanora tartarea* and the *Rocella tinctoria*. Its coloring matter is supposed to be erythrin, whose color is red; but it assumes the blue color, during the process of extracting the litmus from the lichen. The change is supposed to be owing to the loss of oxygen.

3. Blue and red coloring matter of flowers. The expressed juice of most red flowers is blue; and it has therefore been inferred, that the coloring matter in the petals is reddened by an acid, which makes its escape when the flower is exposed to the air. If the petals of the red rose be triturated with a little water and chalk, a blue liquid is obtained, which is rendered green by alkalies and finally restored to red by acids.

4. Red coloring matters. Madder is the root of the *Rubia tinctorum*. It has a reddish brown color. It contains two coloring matters, one of which is yellow, called xanthin, and soluble in cold water: the other is red, and called alizarin, and insoluble in cold water. Alizarin is insipid and destitute of smell. It may be sublimed in long capillary needles, having an orange color. It is soluble in hot water, in alcohol and ether, and the strong acids. With alkalies, it forms soluble compounds, having a violet or lilac color; with alumina, a precipitate which is reddish brown, and with the metallic oxides, insoluble compounds of

a violet or reddish brown color. It likewise has an affinity for various animal matters, such as the white of eggs and bones.

Archil and cudbear. Archil is prepared from *Parmelia rocella* and various other lichens. Cudbear is made from *Lecanora tartarea* and *Parmelia omphalodes*, by steeping the lichens for some time, and leaving them in flat vessels, moistened with ammonia. When the purple color is sufficiently developed, the whole is dried in the open air, and reduced to a fine powder. Neither archil nor cudbear impart fast colors to cloth; but they are used to heighten the brilliancy of other colors.

Safflower is derived from the *Carthamus tinctorius*: its flowers contain two coloring matters, the first of which is soluble in water, and yellow; the second is a pure red, and insoluble in water. It is called carthamin.

Logwood is the wood of the *Hæmytoxylon Campeachianum*. Its sp. gr. is higher than water. Its coloring matter is called hæmatin, and is sometimes so abundant as to exist in the wood in large crystals. It dissolves in 1000 of water, and is very soluble in alcohol and ether. It combines with the acids. The alkali-fiable bases give a solution of hæmatin a violet, purple or blue color. With the fixed alkalies, it forms blue compounds, which are soluble, if atmospheric air be excluded. The alkaline earths precipitate in combination with it, and have a purple color, when from neutral salts, and a blue color, when from sub-salts. The compound which hæmatin forms with alumina and oxide of copper, may be fixed upon linen and cotton; and gives a blue color, like that of indigo. Logwood is chiefly employed by the calico-printers, to give cotton a black or a brown color.

Brazil-wood, the wood of several species of *Cæsalpina* which grow in Brazil and Pernambuco. Its coloring matter is called brazilin. It is soluble in water and alcohol. Its fine red color does not appear, till all the acid which it naturally contains, is saturated. A very minute quantity of alkali gives the infusion of Brazil-wood a violet color, in consequence of which, it is employed as a delicate reagent for alkalies. Brazil-wood has of late been superseded by camwood, which is brought from Africa.

Red sanders is the name of the wood of the *Pterocarpus santalinus*, a tree which grows in India. Its coloring matter is

called santalin. It is tasteless and almost insoluble in water, but is readily taken up by alcohol. It is also dissolved by the alkalies. In India, it is used for dyeing silk and cotton. Druggists use it for coloring tinctures.

Cactin. A carmine-red color, obtained from the flowers of *Cactus speciosus*, by means of weak alcohol.

Yellow coloring matters.

Quercitron bark is the inner bark of the *Quercus nigra* of this country. It contains a good deal of tannic acid along with the coloring matter, which has been called quercitron. It is composed of small scales of a yellow color. It is scarcely soluble in water; but abundantly taken up by alcohol and ether. Solutions of alum strike with it, a beautiful yellow color.

Old Fustic is the wood of the *Morus tinctoria*, a large tree which grows in Brazil and the West Indies. The coloring principle is called morin. It is scarcely soluble in boiling water. It is somewhat soluble in alcohol, and still more so in ether. The alkalies and alkaline earths give it a fine, yellow color.

Weld is the name applied to the dried leaves and stem of the *Reseda luteola*, a plant which is a native of Britain. Its decoction has a brownish yellow color, which acids render paler; but alkalies, common salt and sal-ammoniac, deepen it. A solution of alum, or of protochloride of tin, throws down a fine, yellow lake. The coloring principle of weld is called luteolin. It is obtained by sublimation.

Persian berries are the fruit of the *Rhamnus infectorius* of the Levant. They afford a beautiful, yellow coloring matter, which is united to a substance insoluble in ether, but very soluble in water.

Anotta, a name given to the pulp of the seeds of the *Bixa orellana*, a shrub growing in South America. When separated from the substance with which it is associated in the coccus, it has a fine red color. It is soluble in water and alcohol; and is dissolved by caustic potassa and the alkaline carbonates. Besides the red, anotta contains a yellow coloring principle.

Turmeric is the root of the *Curcuma longa*, a native of the East Indies. Its yellow coloring matter is called curcumin; and may be obtained by digesting turmeric in boiling alcohol, filter-

ing the solution, and evaporating to dryness. It is very soluble in water, alcohol, ether, the volatile and fixed oils. Potassa, soda, baryta, and strontita, change its yellow color to reddish brown; hence its use as a reagent, to determine the presence of an alkali.

Saffron consists of the dried stigmas of the flower of the *Crocus sativus*. Its coloring matter has been called polychroite. It is intensely yellow. It is employed in medicine chiefly as a coloring matter, it being too fugitive for a dye.

Sumac (or young fustic) is applied to the dry and powdered branches of the *Rhus coriaria*, a shrub cultivated in Europe for the use of the dyers and leather-dressers. It yields an orange-yellow color.

Yellow flowers afford a color which is much more persistent, than that of blue or red flowers. It is not altered, except in tint, either by acids or alkalies. The *Parmelia parietina*, so common upon walls and trees, has a fine, yellow coloring matter, which is soluble in boiling alcohol, from which it is precipitated as the alcohol cools, in the form of long brilliant plates.

Green coloring matters.

Chlorophyllite, or chromulite, is obtained by bruising the green leaves into a pulp with water, pressing out all the liquid and boiling the dry pulp in alcohol. When the alcohol is evaporated, the chlorophyllite remains in the state of a deep, green matter. It is slightly soluble in hot water: but it is taken up by acetic acid. The change of leaves in autumn from green to yellow or red, is conceived to arise from modifications of one and the same color. Leaves at this season of the year absorb, instead of emitting oxygen, the consequence of which is, the formation of an acid, which changes the chromulite first to yellow and then to red.

FIXED OILS.

These have been divided into three groups, viz. 1, drying oils; 2, fat oils; 3, solid oils.

1. *Drying oils.* These oils gradually dry when exposed to the air, into a hard, transparent varnish. Mode of preparing drying oils;—changes they undergo in the process.

Linseed oil is obtained from the ripe seeds of the *Linum usitatissimum*, or common flax, which yield about 22 p. c. of their weight of it. It becomes solid, at about zero. Soluble in 5 times

its weight of boiling alcohol, and in about once and a half its weight of ether.

Oil of walnuts is expressed from the fruit of the *Juglans regia*. It is more desiccative than linseed oil, and is used in the finer kinds of painting.

Oil of hempseed, from the seed of the *Cannabis sativa*, or hemp. It is used for lamps in Russia; also for making soap and varnishes.

Poppy oil, from the seeds of the *Papaver somniferum*. It resembles olive oil, and is used as an article of food in France and Germany.

Castor oil, obtained from the seeds of the *Ricinus communis*. Its sp. gr. = 0.95, at 77°. It boils at 509°. At zero, it congeals into a yellow, transparent mass. It becomes rancid, when exposed to the air. It may be mixed in all proportions with alcohol and ether; and when so mingled, it lets fall the foreign bodies it may contain. When castor oil is mixed with $\frac{1}{20}$ th its weight of hyponitrous acid (diluted with 3 parts of nitric acid), it becomes solid in about seven hours. The solid substance thus produced, is called palmin. When palmin is melted and treated with solution of potassa, a soap is formed; from which hydrochloric acid separates a crystalline mass, called palmic acid. Castor oil is well known as an excellent purgative.

Croton oil, obtained by expression from the seeds of the *Croton tiglium*. Its smell resembles jalap, and its taste is acrid. Soluble in alcohol and ether. It owes its purgative qualities to a portion of crotonic acid dissolved in the oil. The acid may be separated by saponification.

2. *Flat oils*. These, like the drying oils, become solid by long exposure, the solid having the appearance of tallow.

Olive oil, expressed from the fruit of the *Olea Europæa*, or common olive. Its sp. gr. = 0.9109. It congeals at 36°, depositing little spheres of stearin. At 21° it deposits 28 p. c. of stearin, and leaves 72 p. c. of elain. Olive oil is solidified by hyponitrous acid; and the solid matter into which it is changed, is called elaidin. This is easily saponified when mixed with solution of potassa or soda; and on decomposing the soap with hydrochloric acid, the fatty acid, called elaidic acid, is separated. Olive oil takes the place of butter, in dressing food in some countries: it is likewise used by watch-makers.

Oil of almonds, from the fruit of the *Amygdalus communis*.

Rape-seed oil, obtained by expressing the seeds of *Brassica rapa* and *napus*. At 28° , it congeals into a yellow mass: it contains 46 parts stearin and 54 of elain. A rapeseed oil from the *Brassica campestris*, is much used in France as a lamp-oil.

Oil of mustard, from the seeds of the *Sinapis alba* and *nigra*. It has an amber color, is destitute of smell, and thicker than olive oil. It makes an excellent soap.

Tea oil; it is not derived from any species of the tea plant, but comes from the fruit of the *Camellia oleifera*, or *sesangua*. It is much used in China for food, as well as for lamps.

Laurel oil, from the berries of the *Laurus nobilis*.

Oil of alyssum, from the seeds of the *Alyssum sativum*.

SOLID OILS.

These are obtained from plants in the solid state. Butter of cacao, extracted from the seeds of the *Theobroma cacao*. It has the smell of the seed, an agreeable, chocolate taste, and the consistence of tallow. Sp. gr. = 0.91: melts at 122° . It does not become rancid on long keeping; and is hence employed by apothecaries, in the preparation of ointments.

Palm oil, extracted from the *Cocos butyraceæ*, or from *Avoira elais*. Color, orange yellow: consistence that of butter; an odor similar to that of violets. It is much used in the manufacture of yellow soap.

Butter of nutmeg, from the fruit of the *Myristica aromatica*, or *moschata*. It consists of two colorless oils, similar to tallow, of a fat, butter-like oil, and one which is volatile and odoriferous. It is employed in medicine. It is often imitated by boiling animal fat with nutmeg, and coloring with safflower: but such a mixture will not dissolve, in four times its weight of alcohol.

Cocoa-nut oil, obtained from the expression of the cocoa-nut, the fruit of the *Cocos nucifera*. It is white, and hard in its consistence. It is used in soap-making.

Butter of illipé, extracted from the seeds of the *Bassia latifolia*, a tree of Bengal. It is solid at 73° . Its color and odor resemble olive-oil. It combines readily with alkalies, and forms an excellent soap.

Bees'-wax, though an animal production, closely resembles the wax from plants. As it comes from the bee-hive, it has a yellow color and peculiar smell, derived from the honey. When purified, it is snow-white, and without taste or smell. Sp. gr.=0.96. At a high temperature, the wax boils and evaporates, taking fire at a red heat, and burning with a bright flame: hence its use in making candles. Bees'-wax contains two kinds of wax, called cerin and myricin; boiling alcohol dissolves the former, but not the latter.

Myrtle-wax, or bayberry-tallow, obtained from the berries of the *Myrica cerifera* of this country. The berries are thrown into a kettle and boiled with water: the wax melts and rises to the surface. Its color is pale green. Sp. gr.=1.05. When strongly heated, it burns like bees'-wax.

Brazil-wax, from an unknown tree, which grows in Brazil.

Japan-wax, from Canton. Color, white; softer than bees'-wax. Sp. gr.=0.97.

Fossil-wax of Moldavia.

Cow-tree wax, or galactin, exists in the milk of the cow-tree, or *Galactodendron utile* of South America. It is opaque, and has the consistency of wax. It is soft and ductile at 60°. It is fluid, at 137°. It is as tasteless as wax. Soluble in hot alcohol and ether: but does not dissolve in the alkalies.

Wax of *Ceroxylon andicola*, is scraped from the bark of this tree, which grows in South America. It is made up into balls, and dried by exposure in the sun. It melts at a little above 212°. Soluble in hot alcohol, also in ether: the alkalies attack it with difficulty.

Additional table of fixed oils.

Names.	Plants from whence obtained.
Nut-oil,	<i>Corylus avellana</i> .
Oil of sesamum,	<i>Sesamum orientale</i> .
Oil of behen,	<i>Guilandina Mohringa</i> .
Cucumber oil,	<i>Cucurbita pepo et metapepo</i> .
Beech-mast oil,	<i>Fagus sylvatica</i> .
Oil of sunflower,	<i>Helianthus annuus et perennis</i> .
Tobacco-seed oil,	<i>Nicotiana tabacum et rustica</i> .
Plum-kernel oil,	<i>Prunus domestica</i> .

Grape-seed oil,	<i>Vitis vinifera</i> .
Ground-nut oil,	<i>Arachis hypogae</i> .
Dittander oil,	<i>Lepidium sativum</i> .
Oil of deadly nightshade,	<i>Atropa belladonna</i> .
Myagrum oil,	<i>Myagrum sativum</i> .
Rocket oil,	<i>Hesperis matronalis</i> .
Scotch fir-seed oil,	<i>Pinus sylvestris</i> .
Spindle-tree oil,	<i>Euonymus Europæus</i> .

Volatile oils.—These have been divided into three sets. 1. Those that contain only carbon and hydrogen. 2. Those that contain carbon, hydrogen, and oxygen. 3. Oils which contain in addition to the foregoing ingredients, the element of sulphur, and probably, that of nitrogen also.

Division 1. Six species have been found to belong here. They are all lighter than water, and seem to have the property of combining in definite proportions with acids, and may therefore be considered as bases.

Oil of turpentine, obtained from a viscid, semi-fluid substance, called turpentine, which flows from various species of the genus *Pinus*. The volatile oil is obtained by distilling a mixture of turpentine and water. The residue in the still, is common resin, or rosin. Oil of turpentine, when cooled down to -17° , deposits white crystals of stearin. Oil of turpentine boils at 313° . It absorbs a great quantity of hydrochloric acid (163 volumes), and forms a crystallized substance, having much resemblance to camphor: it is called artificial camphor. At the temperature of 68° , it is so soft, that it may be kneaded between the fingers; but at 52° it is brittle. It yields on decomposition a clear, transparent oil, not at all like oil of turpentine, and which has been called dadyl: but DUMAS obtained an oil from artificial camphor, which presented all the properties of oil of turpentine. It boiled at 313° , and was composed of 10 atoms carbon + 8 of hydrogen. It was called camphene, by DUMAS. Artificial camphor is supposed to consist of one atom camphene (oil of turpentine) + 1 atom of hydrochloric acid.

Oil of lemons, extracted from the rind of the lemon. Boiling point, not far from 313° . Soluble in alcohol. It absorbs hydrochloric acid, and forms a species of camphor, called muriate of

citrene, and consists like artificial camphor, of 1 equivalent of citrene + 1 of hydrochloric acid. The base of this salt (citrene) has been separated and analyzed. Its composition is identical with camphene.

Orange-flower oil, from the distillation of orange-flowers. When heated with alcohol of the sp. gr. of 0.842, 1 p. c. of a white precipitate is thrown down, which is odorless and tasteless. It melts at 131° , forming a kind of wax. It is called aurade.

Juniper berry oil, obtained by distilling pounded juniper berries along with water. Its sp. gr. = 0.911. It is employed in medicine as a diuretic.

Oil of pepper, extracted from common pepper. It has the smell, but not the taste of pepper. In composition, it is identical with oil of turpentine.

Oil of sabine, obtained from the leaves of the *Juniperus sabina*.

Oil of cedar, obtained from the *Thuya occidentalis* of this country.

Division 2. The oils of this group are as heavy, or heavier than water, and seem to have the property of combining in definite proportions with bases, and are therefore analogous to acids.

Oil of cloves, extracted from the unripe fruit of the *Eugenia caryophyllata*, or clove-tree. It has the smell and hot taste of cloves. Sp. gr. = 1.034. It is the least volatile of all the volatile oils. When mixed with oil of turpentine, the latter can be completely separated by distillation. It deposits after long keeping, a solid crystalline matter, called eugenin. Oil of cloves combines with alkaline bases, forming numerous compounds (many of which are crystallizable). Ammoniated clove-oil. Clove-oil potassa. Clove-oil baryta. Clove-oil lime. Clove-oil lead.

Oil of cinnamon, already mentioned under the head of vegetable acids.

Volatile oil of bitter almonds, obtained by distilling bitter almonds with water. Heavier than water, and has the odor of prussic acid. Exposed to the air, it absorbs oxygen, and deposits an abundance of white crystals.

Oil of bergamot, obtained from the ripe fruit of the *Citrus bergamium*. It is limpid, yellowish and fluid. Sp. gr. = 0.88. It becomes solid a little below 32° . Much used as a perfume.

Oil of roses (ottar of roses), obtained by distilling the petals of the *Rosa centifolia* along with water. Sp. gr.=0.86. Below 80° , it congeals like butter. It is composed of two oils, one liquid, the other solid, the latter being odorless.

Oil of jonquille, from the petals of the *Narcissus jonquilla*.

Oil of peppermint, extracted from the leaves of *Mentha piperita*, or common peppermint. Sp. gr.=0.92. That which is made in this country yields crystals, differing from camphor only in containing two additional atoms of hydrogen.

Oil of lavender, extracted from the *Lavandula spica*. Sp. gr.=0.87 to 0.90. The alcoholic solution of this oil is much used as a perfume.

Oil of rosemary, extracted from the *Rosmarinus officinalis*, or common rosemary. It resembles oil of turpentine in color and fluidity. Sp. gr.=0.88. It boils at 329° . When kept in imperfectly stopped phials, it gradually deposits crystals, which have been considered as camphor.

Oil of anise, extracted from the seeds of the *Pimpinella anisum*. Sp. gr. at 78° =0.98. It gradually becomes solid when kept at 50° .

Oil of cajeput, prepared by distilling along with water, the dry leaves of *Melaleuca leucadendron*. Color, green. Sp. gr.=0.91. Taste, hot; smell, strong and disagreeable. It boils at $343\frac{1}{2}^{\circ}$. Much used as a stimulant in medicine.

Oil of mint, prepared by distilling the leaves of the *Mentha crispa*.

Oil of fennel, obtained from *Anethum fœniculum*. Sp. gr.=0.99. It crystallizes when cooled below 50° .

Oil of dill, obtained from the seeds of the *Anethum graveolens*.

Oil of chamomile, extracted from the flowers of the *Matricaria chamomilla*, or feverfew. Color, deep blue. It is thick and almost opaque.

Oil of nutmegs. There are two oils from the nutmeg, viz. a fixed oil, which is extracted by expression, and a volatile oil, which is obtained by distillation with water. This last is nearly colorless. Sp. gr.=0.92. When kept, it deposits a solid, crystallized matter, which has been considered as camphor.

Oil of tansy, extracted from the leaves of *Tanacetum vulgare*, or common tansy.

Oil of asarum, obtained from the *Asarum Europæum*.

Oil of caraway, extracted from the seeds of the *Carum carui*.

Oil of pimento, extracted from the covering of the fruit of the *Myrtus pimenta*.

Oil of parsley, from the *Apium petroselinum*. On keeping, it lets fall a solid portion, which appears to be camphor.

Oil of sassafras, obtained from the root of the *Laurus sassafras*. When fresh, it is colorless; but by keeping becomes yellow, or even red. Sp. gr. = 1.09. When agitated with water, it separates like oil of parsley into 2 portions, a fluid which swims on the surface, and a heavier oil which falls to the bottom. It scarcely combines with the caustic alkalies.

Oil of basil, from the *Ocymum basilicum*. It deposits a crystalline solid.

Oil of hops, obtained by distillation, or by means of alcohol, from the blossoms of the hop, the *Humulus lupulus*. Sp. gr. = 0.91. It changes by keeping into a kind of resin.

Oil of whisky, obtained from the barley, out of which whisky is made. It dissolves in 6 times its weight of alcohol, and in twice its weight of ether. Its color is white: and it becomes solid like tallow, at a low temperature. Its taste is disagreeable. Whisky may be deprived of this oil, by animal charcoal, but it injures the flavor of the spirit.

Oil of brandy, obtained by distilling the fermented residue of grapes. It distils over after the brandy has passed. It is limpid, has a strong smell, and an acrid taste.

Oil of potatoes, extracted from potatoe whisky. A colorless, limpid liquid, having a strong smell, and a hot acrid taste. Boils at 257° , and congeals at a little below zero.

3. *Acrid and vesicating oils*. These are believed to contain both nitrogen and sulphur; and it has been supposed that their vesicating property might be owing to the presence of sulphur.

Oil of mustard. It does not exist ready formed in the seeds of the plant, but is generated by the action of water during the process of distillation. Its color is usually brown; but it may be rendered colorless. Sp. gr. = 1.01 at 68° . It boils at $289\frac{1}{2}^{\circ}$. Odor, strong and penetrating. It consists of $S^2\frac{1}{2}C^16H^10N^2O^2\frac{1}{2}$.

Oil of horse radish, extracted from the *Cochlearia armoracia*, or horse radish. It is heavier than water. Odor, very strong. It is slightly soluble in water, to which it communicates its smell, and property of inflaming the skin. It is soluble in alcohol.

Scurvy-grass oil, extracted from the *Cochlearia officinalis*, or scurvy-grass. Color, yellow; odor, strong, exciting tears: heavier than water. The alcoholic solution is known in medicine under the name of spirit of cochlearia.

Oil of garlic, extracted from the bulbs and stem of the *Allium sativus*, or garlic. Heavier than water; very volatile. Applied to the skin, it occasions violent pain. When burnt, it emits a sulphureous odor.

Table of volatile oils, in addition to the foregoing.

Name.	Plants in which found.	Parts of the plant.
Oil of Wormwood,	<i>Artemisia absinthium</i> ,	Leaves.
" Sweet flag,	<i>Acorus calamus</i> ,	Root.
" Jamaica pep.,	<i>Myrtus pimenta</i> ,	Fruit.
" Mugwort,	<i>Artemisia vulgaris</i> ,	Leaves.
" Carlina,	<i>Carlina acaulis</i> ,	Roots.
" Chervil,	<i>Scandix chærefolium</i> ,	Leaves.
" Copaiva,	<i>Copaifera officinalis</i> ,	Extract.
" Coriander,	<i>Coriandrum sativum</i> ,	Seeds.
" Culilaban,	<i>Laurus culilaban</i> ,	Bark.
" Cumin,	<i>Cuminum cyminum</i> ,	Seeds.
" Elecampane,	<i>Inula helenium</i> ,	Roots.
" Cascarilla,	<i>Croton eleutheria</i> ,	Bark.
" Galanga,	<i>Maranta galanga</i> ,	Roots.
" Hyssop,	<i>Hyssopus officinalis</i> ,	Leaves.
" Laurocerasus,	<i>Prunus laurocerasus</i> ,	Leaves.
" Lovage,	<i>Ligusticum levisticum</i> ,	Roots.
" Mace,	<i>Myristica moschata</i> ,	Seeds.
" Marjoram,	<i>Origanum majorana</i> ,	Leaves.
" Motherwort,	<i>Matricaria parthenum</i> ,	Plant.
" Balm,	<i>Melissa officinalis</i> ,	Leaves.
" Millefoot,	<i>Achillea millefolium</i> ,	Flowers.
" Spanish hop,	<i>Origanum creticum</i> ,	Flowers.
" Pennyroyal,	<i>Mentha pulegium</i> ,	Flowers.

Name.	Plants in which found.	Parts of the plant.
Oil of Rhodium,	Genista canariensis,	Root.
" Rue,	Ruta graveolens,	Leaves.
" Sage,	Salvia officinalis,	Leaves.
" Thyme,	Thymus serpyllum,	{ Leaves and Flowers.
" Zedoary,	Kæmpferia rotunda,	
" Ginger,	Amomum zingiber,	Root.

4. *Camphors*. The term camphor has been applied to various solid bodies which occasionally appear in volatile oils; and which are characterized by their volatility, peculiar odor, the property of melting when heated, and burning brilliantly when held to a lighted candle.

Common camphor, obtained from the *Laurus camphora*, a tree common in the East, by distilling its wood along with water, in large iron pots, to which are fitted earthen heads stuffed with straw. It is refined by a second sublimation. Its sp. gr. = 0.98: it melts at 288° . It crystallizes in octahedrons, and in six-sided plates. It is insoluble in water, but is readily soluble in alcohol, oils and acids. When it is driven in vapor across red hot lime in a porcelain tube, a peculiar liquid is obtained, called camphrone.

Camphor, consists of	$C^{12}H^9O^1$
Camphrone "	$C^{24}H^{17}O$

Camphor from oil of peppermint. Prismatic crystals of this substance make their appearance when the American oil of peppermint is cooled down, to within a few degrees of 32° . The crystals are white, melt at 77° , and may be volatilized without decomposition. They differ from common camphor, by containing 2 atoms more of hydrogen.

Camphor from oil of anise. In composition, it agrees with the camphor from oil of peppermint.

Camphor from oil of cubebs. It is obtained in crystals from the oil. They are soft, and easily reduced to powder. The smell is similar to that of cubebs. They melt at 157° . They dissolve readily in alcohol and ether. The acids act on them slowly, effecting their decomposition. They consist of $C^{16}H^{14}O$.

Asarin, a substance analogous to camphor, obtained by distilling the roots of the *Asarum Europæum* with water, after allowing them to macerate during 24 hours. The roots yield two crystallized bodies, one called asarin, the other asarite. The latter presents itself in small silky needles, destitute of taste and odor. Sp. gr. at $158^{\circ}=0.95$. By heating, it melts into an oily fluid, and is finally volatilized in a white vapor, which is very irritating. Asarin, on the contrary, is volatilized without any irritating odor. Water throws it down from its alcoholic solution, in cubes or prisms with six faces.*

RESINS. They are obtained either by exudation from trees, or by digesting the substances containing the resin in alcohol. Those which flow out from openings in the plants, do so in the summer, and are held in solution by volatile oils, which, when the exudation is exposed to the air, either make their escape, or are themselves converted into resin by the absorption of oxygen. Resins are solid substances, naturally brittle, non-conductors of electricity, and heavier than water. Their taste is insipid, and they are without odor, except from the presence of volatile oil. When heated, they melt; and if the heat be increased, they take fire and burn with a yellow flame. Insoluble in water; but are soluble in alcohol, and mostly so, in volatile and fixed oils. They unite with the alkalies, forming soaps; although they are not all of them possessed of an equally strong affinity for bases.

Resins have been divided into two sets, viz. semi-fluid resins, or balsams, and solid resins.

I. Balsams. These owe their plastic, or semi-fluid state, to the presence of a certain quantity of volatile oil which they contain, and which may in general be separated by distillation.

Turpentine exudes in a semi-fluid state from various species of the pine; but in this country, is obtained from the *Pinus australis*, or long-leaved pine, which abounds in the lower parts of the Carolinas, Georgia, and Florida. It is obtained by making incisions into the bark. The turpentine begins to exude about the middle of March, flowing with increasing abundance through the months

* LEOPOLD GMELIN mentions 32 species of camphor obtained from volatile oils, in his *Handbuch der Theoretischen Chemie*, II, 403. (1829.)

of July and August.* It is composed of the oil of turpentine and two resins, called by the names of pinic and sylvic acids, and by BERZELIUS, resin alpha and resin beta of turpentine. The volatile oil varies, from 5 to 25 p. c. of the turpentine; and the two resins are no less variable in their quantity. To separate the three bodies, the turpentine is mixed with water and distilled: the oil of turpentine is thus expelled. The residue is dried, and after being reduced to powder, is digested in alcohol of sp. gr. = 0.867. It dissolves the pinic acid, but leaves the sylvic acid. Venice turpentine comes from the *Pinus larix*, or common larch of Europe. It contains from 18 to 25 p. c. of the oil of turpentine; the remainder is colophan, or common resin. Strasburg turpentine is extracted from the *Pinus picea*. Its alcoholic solution deposits, on evaporation, a resin called abietin. It combines with alkalies; and their compounds, when decomposed, yield the abietic acid. Turpentine from the Carpathian mountains and Hungary: the first is derived from the *Pinus cembra*, the second from the *Pinus mugos*. Canada balsam is obtained from the *Pinus canadensis* and *Pinus balsamea*. The turpentine of Cyprus and Clio is extracted from the *Pistacea terebinthus*. Its odor is agreeable when pure; but it is often adulterated by being mixed with cheaper turpentines.

Balsam of copaiva, obtained from the *Copaifera officinalis*, and several other species belonging to the same genus, all of which are natives of Brazil and the Antilles. It exudes from incisions made in the bark of the tree. Sp. gr. = 0.95. Insoluble in water; but dissolves in all proportions in alcohol, ether, the fixed and volatile oils. It readily combines with salifiable bases. With potassa, it forms a soluble compound. It does the same with soda and ammonia. At 504°, the balsam boils and the distillation goes on briskly, a limpid yellowish oil passing over. This oil boils at 473°. Copaiva is sometimes adulterated by fixed oils, from which the balsam may be separated (with the

* Tar is an impure variety of turpentine, obtained by burning the dead trees in kilns, well covered with earth. As the combustion proceeds, the tar flows out from the base of the cone, and is caught in barrels. When tar has been reduced one half by evaporation, it forms pitch.

exception of castor oil) by means of alcohol, which does not take up the oils. It is prescribed as an expectorant.

Balsam of Peru, obtained from the *Myroxylon peruiferum*, a native of South America. At 617° , it yields about half its weight of a volatile oil, which is much less volatile than the other volatile oils: benzoic acid is at the same time evolved. The balsam is a deep brown, viscid fluid, of a fragrant odor, and a warm and bitterish taste. It is used externally in the cure of ulcers, and sometimes internally as an expectorant.

Balsam of Tolu, obtained from the *Tulifera balsamum*, a tree of South America. The color is reddish brown, and after exposure to the air, becomes brittle. It is wholly soluble in alcohol, ether, and the alkalies. It operates as a stimulant expectorant.

Liquid Styraç, or liquid amber, exudes from the *Liquidambar* (sweet-gum), a tree which is a native of this country and of Mexico. It has an oily consistence, a strong smell, and a sharp acid taste. It floats on water. Alcohol at $91\frac{1}{2}^{\circ}$ dissolves $\frac{2}{3}$ of this balsam. The resin which is not taken up by alcohol, is called styracin. A liquid and transparent volatile oil is obtained by distilling it along with water.

Opobalsamum, or balm of Gilead (balm of Mecca), obtained from the *Amyris Gileadensis*, and *A. opobalsamum*, a tree of Arabia. It has the consistence of turpentine, and the color of honey. When rubbed between the hands, it froths like soap. It does not wholly dissolve in alcohol. The matter which is insoluble has received the name of burserin. It affords a volatile oil, on being distilled along with water.

China varnish comes from a Chinese tea called *Augia sinensis*. It has the same consistence as turpentine. It constitutes the best varnish hitherto discovered.

Division II. *Solid Resins.*

Rosin, or colofan, the name given to the dry residuum, after the volatile oil has been expelled from the different species of turpentines. When it has a golden yellow color, it is called Burgundy pitch. Rosin is composed for the most part of pinic acid, which by further distillation by itself in a retort, is converted into a brown resin, called colophanic acid. Common rosin often contains $\frac{1}{6}$ of its weight of this acid. When rosin is distilled *per se*, or along

with lime, there passes over a very heavy, light colored oil, which is scarcely soluble in alcohol or water. It is called resinoin.

Mastich is obtained from the *Pistacia lentiscus*, a tree which grows in the Levant. It comes in the form of yellowish, transparent grains. It has but little taste; but gradually softens in the mouth. It is largely used in Turkey for strengthening the gums, and to sweeten the breath.

Sandarach, from the *Thuya articulata*, of Barbary. Resembles mastich. It melts at 308° , and gives out an agreeable odor. It has been found to contain three distinct resins; of which, resin alpha much resembles pinic acid.

Elemi, from the *Amyris elemifera*, of South America, and the *A. ceylonica*, of Ceylon. It is of a pale, yellow color. It is soluble in alcohol, and is often employed as a varnish.

Tacamahac, from the *Calophyllum Inophyllum* of Madagascar.

Labdanum, from the *Cistus creticus*, of Syria.

Botany Bay resin, from the *Acarois resinifera*, of New Holland.

Guaiacum. This resin is obtained from the wood of the *Guaiacum officinale*, a native of the West Indies. By igniting one end of a billet of the wood, the guaiacum exudes from the other. Its color is greenish brown. It breaks with a shining, vitreous fracture: it softens in the mouth, and melts at a low heat, emitting an agreeable odor. It is freely soluble in alcohol, and the alkalis. It is much employed in medicine. To discover whether it be adulterated with common rosin, it is treated with solution of potassa, in which the guaiacum only dissolves.

Storax, from the *Styrax officinalis*, of the Levant. It is the most fragrant of all the resins. It comes in the form of concrete tears, of a yellowish, or reddish yellow color. It was formerly used as a stimulant expectorant, but it has been replaced by the balsams of Peru and Tolu.

Dragon's blood. It is probably obtained from several different plants. That which is brought from India, is furnished by the *Calamus draco*. It is brittle and tasteless; but affords a deep red solution, with alcohol. It is also soluble in oils. When the resin is treated with dilute sulphuric acid, a yellow colored solution is obtained; and an undissolved substance is left behind, which has

been called dracin. Dracin has been considered a vegetable alkaloid. Its color is red. It dissolves readily in alcohol.

Dammara, from the *Pinus dammara* (*Dammara alba*), of the East Indies. It is transparent and colorless. It is easily melted, and is soluble in alcohol. When mingled with $1\frac{1}{2}$ its weight of turpentine, an excellent varnish is formed for lithographic engravings.

Benzoin, the produce of the *Styrax benzoe*, a tree of Sumatra. Besides benzoic acid and a volatile oil, it contains three resins. Benzoin is wholly soluble in alcohol and in solution of potassa. It is advantageously used as a stimulant expectorant.

Copal. This resin flows spontaneously from the *Rhus copalinum* of South America, and from the *Elæocarpus copaliferus* of the East Indies. It is also collected from the sand, on the shores of Guinea. It is nearly white, and transparent. It melts like other resins; but is dissolved with considerable difficulty, either in alcohol or oils: nevertheless, it is brought into solution by these menstrua, and largely employed as a varnish. The African copal has been found by UNVERDORBEN to contain, no fewer than five different resins.

Lac, deposited by different species of the *Ficus*. In its natural state, it is called stick lac: when detached from the little twigs, and boiled in water, it is called seed lac: when melted, and reduced to the state of a thin crust, it is called shell lac. It contains no fewer than five resins, a fatty matter, a peculiar principle, called laccin, and a red coloring matter. The principle use of lac is in the fabrication of sealing-wax.*

Amber, though found in beds of wood coal, is undoubtedly of vegetable origin. The sp. gr.=1.06. It is sometimes nearly colorless, but more commonly is yellow, or brown. When heated, it softens; in a strong heat, it burns, leaving a small quantity of ashes. By long digestion, alcohol dissolves one eighth of its weight of amber. When treated with a boiling solution of potassa,

* The best kind of sealing-wax consists of 48 shell lac, 19 Venice turpentine, 1 balsam of Peru, and 32 of cinnabar, in fine powder. In cheaper kinds of wax, the lac is replaced by rosin, and the cinnabar by red lead. The finest black sealing-wax is made of 60 shell lac, 10 turpentine, 30 levigated ivory black. The coloring matter of yellow-wax, is chromate of lead; that of blue, cobalt; and that of green, is oxide of copper.

it is almost wholly dissolved, forming a soap. Amber contains a volatile oil, two resins soluble in alcohol and ether, succinic acid, and a bituminous substance, which resists the action of all solvents, and constitutes the greater part of amber.

Gum-resins.—These are the milky juices which exude from certain plants, and which on exposure to the air become solid. They are commonly opaque, and possessed of a fatty appearance. They do not melt when heated, though they often swell. They burn with a flame. They have a strong smell (often alliaceous). Taste, acrid. They are partially soluble in alcohol, and partially so in water, their best solvent being a mixture of the two, or proof spirits. They are soluble in alkalies, and in concentrated acids. Their sp. gr. is usually greater than that of the resins. In accordance with their medicinal properties, they may be divided into three sets: viz. 1, antispasmodic and expectorant gum-resins; 2, cathartic gum-resins; 3, sedative gum-resins.

I. *Antispasmodic and expectorant gum-resins.*

Ammoniac, from the *Dorema ammoniacum*, a native of Persia. It consists of resin 70·0, gum 18·4, glutinous matter 4·4, water 6·0. Antispasmodic and expectorant.

Galbanum, from the *Galbanum officinale* of Persia. It contains resin 65·8, gum 22·6, with traces of volatile oil, cerasin and malic acid. It dissolves easily in alcohol, ether, and the fixed oils. Medicinal properties, like those of ammoniac.

Assafœtida, obtained from the *Ferula assafœtida*, a native of Persia. It contains resin 48·85, gum with traces of salts of lime and potassa 19·40, volatile oil 9·6, mucilage 6, sulphate with traces of phosphate of lime 6·2. It is to the volatile oil, that it owes its disagreeable smell. Asafœtida is much used in medicine as an antispasmodic: it is likewise employed as an expectorant.

Opopanax, from the *Pastinaca opopanax*, a plant found in the Levant. It contains nearly equal quantities of gum and resin, with 5 p. c. of volatile oil.

Sagapenum, supposed to be the produce of the *Ferula persica*, a plant which is a native of the East. It contains 50 p. c. of resin, 32 of gum, 4 of mucilage, and 3·75 of a volatile oil, which is pale, yellow, and of a disagreeable alliaceous odor. Its medicinal qualities are similar to those of ammoniac and assafœtida.

Olibanum. This is the frankincense of the ancients, and comes from several trees which are natives of the East. The Indian olibanum is derived from the *Boswellia serrata*. Taste, aromatic and acrid. When burnt, it diffuses an agreeable odor. It is composed of resin 56, gum 30, volatile oil 8, and gummy matter 5·2. It is mostly used as a perfume.

Myrrh, from the *Balsamodendron* of Arabia and Abyssinia. Color, reddish brown. Taste, bitter and aromatic. It burns with difficulty. Sp. gr.=1·36. Soluble in alkalies. It consists of resin 23, gum 46, mucilage 12, and volatile oil 2·5. Its alcoholic solution is used as a dentifrice. It is also administered in the form of pills.

Euphorbium, is derived from several species of *Euphorbia*, which grow in the interior of Africa. It is destitute of smell; but though at first insipid to the taste, it afterwards occasions an acrid impression, and even inflames the mouth and throat. It consists of 60 p. c. of resin, with 14 p. c. of wax, together with considerable lignin and traces of volatile oil. When diluted with starch, it is sometimes employed as an errhine in medicine; and occasionally, it is used externally, as a rubefacient.

Bdellium is derived from a shrub which grows in Senegal, the *Heudelotia africana*. Its constituents are resin 59, mucilage 30·6, gum 9·2, and volatile oil 1·2. It has a weak, but disagreeable smell, and a nauseous taste.

II. *Cathartic gum-resins.*

The aloes from Bombay is afforded by the leaves of the *Aloe spicata*: the Barbadoes aloes by the *A. vulgaris*. Aloes has a reddish brown color. It softens in the hand, has a strong and unpleasant taste, and dissolves for the most part in water and alcohol. It contains a resinous matter (insoluble in water), called apotheme by BERZELIUS. The portion of aloes which dissolves in water is called, the bitter principle of aloes. It is much used as an active and brisk purgative.

Scammony, derived from the root of the *Convolvulus scammonia*, a plant which is a native of Syria. It comes in porous masses, which break with a vitreous fracture: it has a disagreeable odor, and a bitter, acrid taste. It is mostly soluble in alcohol. It contains a variable proportion of resin, from 30 to 60 p. c., and

from 30 to 50 p. c. of vegetable debris. The resin of scammony may be rendered colorless by animal charcoal, without injuring its purgative qualities. It is a drastic purgative.

Gamboge, supposed to be derived from the *Xanthochymus ovalifolius*, a native of Siam. It is also produced by the *Cambogia gutta*. It contains from 60 to 70 p. c. of resin, and about 20 p. c. of arabin. It is almost without taste or smell. With water, it forms a turbid, yellow liquid. It is wholly soluble in alcohol. It is employed as a water-color, and in medicine, as a powerfully drastic carthartic.

III. *Sedative gum-resins.*

Opium is the inspissated juice of the *Papaver somniferum*. It comes from the Levant in rounded masses, whose surfaces are covered by the leaves of a species of *Rumex*, in which the moist opium is rolled up. It has a peculiar odor and a very bitter taste. When steeped in water, it softens: but its best solvent is proof-spirits. The following table gives the results of a comparative analysis of opium, by SCHINDLER, from different places.

				From Smyrna.	From Constantinople.	From Egypt.
Morphina,	-	-	-	10.30	4.50	7.00
Codeina,	-	-	-	.25	.52	
Meconin,	-	-	-	.08	0.30	
Narcotina,	-	-	-	1.30	3.47	2.68
Narceina,	-	-	-	.71	0.42	
Meconic acid,	-	-	-	4.70	4.38	
Resin,	-	-	-	10.93	8.10	
Lime,	-	-	-	.40	0.12	
Magnesia,	-	-	-	.07	0.40	
Alumina, ox. iron, silica and phos. lime,	-	-	-	.24	.22	
Salts and volatile oil,	-	-	-	.36	.36	
Mucilage, caoutchouc, fat and lignin,	-	-	-	26.25	17.18	
Brown acid, soluble in alcohol and water,	-	-	-	1.04	.40	
Brown acid, soluble in water: gum and loss,	-	-	-	40.13	56.49	
				96.72	56.49	

Lactucarium, the juice of the *Lactuca sativa*, a plant of India. It is a brittle solid, and has a bitter taste. It is soluble in alcohol. Hitherto, no vegetable alkali has been separated from it. It has occasionally been employed as a substitute for opium.

Upas. There are two kinds of Upas, distinguished by the names of Upas tieuté and Upas anthiar. The latter of these is a

gum-resin, which exudes from the *Anthiaris toxicaria*; the former is an extract from the *Strychnos tieuté*. Upas tieuté acts as a poison, in the same manner as strychnina does. The inhabitants of Borneo dip the points of their arrows (made of bone) into concentrated Upas tieuté. A wound occasioned by one of these poisoned arrows destroys life, by inducing tetanus, within a quarter of an hour. The natives of the Indian islands, employ the Upas anthiar, as well as the Upas tieuté, to poison their arrows.

NEUTRAL VEGETABLE PRINCIPLES.

These have been arranged by Dr. THOMSON, under the following general divisions:—1. amides, or amidets; 2. benzoyl, and its compounds; 3. spiroil and its compounds; 4. sugars; 5. amylaceous substances; 6. gums; 7. glutinous substances; 8. caoutchouc; 9. extractive; 10. bitter principles; 11. products of destructive distillation of vegetable substances; 12. mellon and analogous compounds.

I. *Amides (amidets)*. The term amide is applied to an anhydrous, ammoniacal salt deprived of 1 atom hydrogen + 1 atom oxygen; or to a compound, which, by the addition of an atom of water, can be converted into a salt of ammonia.

Oxamide. When oxalate of ammonia is distilled in a glass retort, there passes over water which holds in suspension a white, flocky matter, which after thorough edulcoration with cold water, is oxamide. It is volatile; not soluble in cold water. It consists of $C^2O^2 + H^2N$. If we add an atom of water (HO), the oxamide becomes $C^2O^3 + H^3N$, or oxalate of ammonia.

Oxamethane (etheroxamide), formed by passing a current of ammonia over a given quantity of oxalic ether.

Succinamide is formed when ammonia is made to act upon anhydrous succinic acid.

Benzamide. When dry ammoniacal gas is made to pass through pure chloride of benzoyl, it is absorbed, and the liquid changes into a white solid, which is a mixture of sal-ammoniac and benzamide. By washing in cold water, and subsequently by a solution in hot water, the benzamide is obtained in a state of purity. Benzamide melts at 239° , and on cooling congeals into a foliated crystalline mass. It is composed of $C^{14}H^5O^2 + NH^2$. The

addition of an atom of water, changes benzamide into benzoate of ammonia.

Asparamide (asparagin). $C^3H^5NO^5 + NH^2$.

Urethan (ether carbamide), formed when chlorocarbonic ether is placed in contact with aqua ammoniæ. $C^6H^7NO^4$.

Sulphamide.

II. Benzoyl, and its compounds.

The volatile oil, or essence of bitter almonds, does not exist ready formed in the fruit; but is formed by the action of water upon the constituents of the oil in the bitter almonds. The oil contains some prussic acid, from which however, it is purified by mixing it with hydrate of potassa and a solution of protochloride of iron, and subsequently subjecting the whole to distillation. The oil thus purified, is limpid; its taste, acrid; and its sp. gr. = 1.04. It boils at 266° . By exposure to the air it absorbs oxygen, and is converted into benzoic acid. The oil consists of $C^{14}H^6O^2$, and benzoic acid of $C^{14}H^5O^3$; so that the oil contains 1 atom more of hydrogen and 1 atom less of oxygen than the acid. Two atoms of oxygen are absorbed, the one unites with 1 atom of hydrogen and forms water, while the other combines with $C^{14}H^5O^2$, and converts it into benzoic acid. $C^{14}H^5O^2$ must be the base of benzoic acid; and the oil must be this base, combined with an atom of hydrogen, or a hydret of benzoyl, as it has been termed by WÖHLER and LIEBIG.

Benzoyl is obtained by passing a current of chlorine through benzoin. It is very soluble in alcohol and ether. Fusible: volatile.

Table of benzoyl, and its compounds.

Benzoyl,	.	.	.	.	$C^{14}H^5O^2$
Hydret of benzoyl, (oil of bitter almonds,)	.	.	.	.	$C^{14}H^5O^2 + H$
Benzoin,	.	.	.	.	$C^{14}H^5O^2 + H$
Benzoic acid,	.	.	.	.	$C^{14}H^5O^2 + O$
Chloride of benzoyl,	.	.	.	.	$C^{14}H^5O^2 + Cl$
Bromide of benzoyl,	.	.	.	.	$C^{14}H^5O^2 + Br$
Iodide of benzoyl,	.	.	.	.	$C^{14}H^5O^2 + I$
Sulphuret of benzoyl,	.	.	.	.	$C^{14}H^5O^2 + S$
Cyanide of benzoyl,	.	.	.	.	$C^{14}H^5O^2 + C^2N$
Benzene,	.	.	.	.	$C^{13}H^5O$

Benzine,	C^6H^3
Benzamide,	$C^{14}H^5O^2 + H^2N$
Benzimide,	$C^{14}H^5O^2 + H^{\frac{1}{2}}N^{\frac{1}{2}}?$
Nitrobenzide,	$2(C^6H^3) + NO^4$
Sulphobenzide,	$2(C^6H^3) + SO^3$
Azotobenzide,	$2(C^6H^3) + N$

Benzoin (camphoride, or camphor of oil of bitter almonds), is formed by leaving the oil of bitter almonds for nine weeks, in contact with a concentrated solution of potassa. It forms transparent, prismatic crystals, which are destitute of taste or odor. It melts at 248° , catches fire easily, and burns with a lively flame.

Chloride of benzoyl is formed by passing chlorine through oil of almonds. Hydrochloric acid gas is evolved in the process: when this ceases, a pure liquid chloride of benzoyl is obtained. Sp. gr.=1.19. It has a very penetrating odor.

Benzone is obtained when benzoate of lime is distilled. It is a thick, amber-colored oil.

Benzin, is a pure bicarburetted hydrogen, which is obtained when benzoic acid is mixed with 3 or 4 times its weight of slacked lime, and the mixture distilled. It is a limpid and colorless liquid. Sp. gr.=0.83. Boils at 187° .

Nitrobenzide, formed when nitric acid is made to act upon benzin.

III. *Spiroil, and its compounds.*

Spiroil is the supposed base of the volatile oil, extracted from the flowers of the *Spiræa ulmaria*. The oil is (according to Löwig) a compound of $C^{12}H^5O^4$ with an atom of hydrogen. This base has not been obtained in a separate state, but it has been combined with oxygen, chlorine, bromine, iodine and hydrogen, and shown to form definite compounds with each.

Hydrospiroilic acid, or the volatile oil of *Spiræa ulmaria*, has a light yellow color; is soluble in water, alcohol and ether. Its taste is hot and acrid. It combines readily with the alkalies and alkaline earths, forming with them compounds which are but slightly soluble. Hydrospiroilate of ammonia, spiroilide of potassium, of sodium, calcium, barium, iron, copper, &c.—

Chloride of spiroil, obtained by passing chlorine gas slowly over the anhydrous hydrospiroilic acid: hydrochloric acid is

evolved, and the volatile oil is completely converted into a white, crystalline mass. It is insoluble in water, but very soluble in alcohol and ether.

Bromide of spiroil.

Iodide of spiroil.

Spiroilic acid, formed by treating hydrospiroilic acid with nitric acid. The oil is changed into a solid, crystalline mass, while nitrous vapors and carbonic acid gas are disengaged. By the action of nitric acid, 1 atom of hydrogen is withdrawn, and 4 atoms of oxygen substituted in its place. Spiroilic acid therefore consists of $C^{12}H^5O^4 + 4$ atoms of oxygen ($=C^{12}H^5O^8$). The spiroilates of the alkalis are soluble in alcohol. When heated in the air, they fulminate; and leave the base either pure, or in the state of a carbonate, together with a charcoal which discolors powerfully.

IV. *Sugars.* The term sugar is applied to various substances, characterized by an agreeable and sweet flavor, and a high degree of solubility.

Common sugar, produced by the cane, the sugar maple, and the beet. When purified, is white, brittle, and phosphorescent, if crushed in the dark. Its sp. gr. = 1.6. Water at 48° , dissolves its own weight; and at 212° , it is capable of dissolving an almost unlimited quantity. Sugar is altered by the action of the strong acids. Strong sulphuric acid blackens it. Nitric acid converts it into oxalhydric and oxalic acids. 480 grains of sugar, in 6 ounces of nitric acid, diluted with its own weight of water, and cautiously heated (separating the crystals as they form), yield 280 grains of oxalic acid. Acids generally, whether organic or inorganic, act upon sugar, even when in very dilute solutions, by first converting them into uncrystallizable sugar, next into sugar of grapes, next into uncrystallizable sugar, then into ulmic acid; and finally, if air be present, into ulmic and formic acids. These changes go on at common temperatures. Sugar combines with the acidifiable bases, losing its sweet taste and its crystalline tendency; but when the base is neutralized with sulphuric acid, unaltered sugar is obtained. Lime has a tendency to convert sugar into gum. Crystallized sugar contains an atom of water. Anhydrous sugar consists of $C^{12}H^{10}O^{10}$.

Liquid sugar. This kind of sugar exists in a variety of fruits and vegetable juices. According to PROUST, it constitutes a considerable portion of molasses. It is afforded by grapes, peaches, apples, and other fruits. It may be obtained likewise, from the stalks of the Indian corn (*Zea mais*). There is reason to believe that liquid sugar is nothing more than common sugar, deprived of the power of crystallization, by the presence of gum or acid, or of both.

Sugar of grapes and starch. Verjuice, or the liquid from unripe grapes, contains tartrate and sulphate of potassa, sulphate of lime, much citric acid, a little malic acid, extractive and water; but neither gum nor sugar. As the grapes attain maturity, the citric acid gradually disappears, and gum and sugar take its place. When the juice is evaporated to dryness, it yields from a third to one fifth of solid matter, of which about 75 parts are crystallizable sugar, and 24 syrup, or uncrystallizable sugar. The sugar is not so sweet as that from the cane; nine from the latter, will go as far as five, of the former. Starch may be converted into a sugar possessing exactly the properties of sugar of grapes, by mixing it with about 4 times its weight of water and about $\frac{1}{100}$ part its weight of sulphuric acid, boiling the mixture for 36 hours, supplying water as fast as it evaporates; then saturating the acid with lime, separating the sulphate of lime, and concentrating the liquid by sufficient evaporation. By a similar process, saw-dust, straw, linen rags, and even the bark of trees, may be converted into the same kind of sugar. Honey is a concentrated solution of grape-sugar. The sugar of grapes differs in composition from common sugar, by containing two additional atoms of water.

Mushroom sugar, from the *Agaricus volvaceus*. It is much less soluble than common sugar; and it is found also, in many other species of the same genus, as well as in a number of allied genera.

Manna. It is the produce of various trees, but is chiefly procured from the *Fraxinus ornus*, which grows abundantly in Sicily and Calabria. To obtain manna in a state of purity, it is only necessary to dissolve the manna of the shops in boiling alcohol. As the solution cools, the sugar (mannite) is thrown down in needle-shaped crystals. It is composed of $C^{12}H^{14}O^{12}$.

Liquorice sugar, the inspissated juice of the roots of *Glycyrrhiza glabra*. Its taste is similar to that of liquorice root. It is soluble both in water and alcohol. With acids, it forms compounds scarcely soluble in water.

Sugar of figs. It concretes upon the outside of the dried fruit.

Sarcocollin forms the chief part of sarcocolla, which comes from Persia and India. It exudes from the *Penæa mucronata*. To obtain the sugar, the grains of sarcocolla are digested in ether, to dissolve a resinous matter which is present: absolute alcohol then takes up the sugar, which is thrown down on the evaporation of the alcohol.

Glycerin (glycerule). The sweet principle of oils. It is obtained by digesting an oil with potassa, to form a soap, which is then decomposed by sulphuric acid. The syrup is dissolved in alcohol, and the alcoholic solution is evaporated; when the glycerin is obtained in a state of purity. Its taste is sweet; but it is uncrystallizable. It consists of $C^6H^7O^5$.

V. *Amylaceous substances.*

Starch is obtained from wheat flour, by kneading it under a stream of cold water, until the water flows off from it, perfectly clear: a tough, greyish white substance, called gluten, remains behind, while the water deposits a white powder, which is known under the name of starch. Manufacturers' process for separating starch.—The purest starch is obtained from the potatoe, one hundred pounds of which, yield fifteen of starch. This principle exists likewise in all seeds of grassy plants used for food, as oats, rice, rye, barley, &c., as well as in the bulbs and tubers of plants generally. It is extracted from the roots of the *Maranta arundinacea* of South America, and goes under the name of arrow-root. Cassava and tapioca are obtained from the roots of the *Jatropha manihot* of South America; sago from the pith of a species of palm, the *Sagus raphia*, a native of India; while the variety called Salop (from Persia) is supposed to be prepared from several species of *Orchis*.

Starch when pure, has a fine white color, is without odor and tasteless. Sp. gr. = 1.53. When moistened and examined under the microscope, it appears in the form of rounded grains, varying in size and shape, according to the species of plants from which it

has been furnished. These rounded grains consist of vesicles, inclosing a clear, transparent, colorless liquid. The envelopes remain entire when the starch is thrown into cold water: but in boiling water, they burst; the central liquid dissolves, and the vesicular envelope becomes much more bulky and transparent than before. The liquid within the covering of the globule, holds in solution a peculiar substance, called amidin: the vesicular covering itself, which is insoluble in water, is called amylin. Anhydrous amidin consists (according to GUERIN) of $C^{14}H^{10}O^8$, but PROUT gives it, as CHO.

Hordein is obtained from barley meal, by forming it into a paste, and washing with cold water: the starch and hordein are washed away. Boiling water dissolves the starch, and leaves the hordein behind. It is a yellow powder, resembling saw-dust, and consists of $C^{11}H^{10}O^{10}$.

Lichenin. This principle was formerly called the starch of the *Cetraria islandica* (island moss), the well known food of the reindeer. It contains about 44 p. c. of lichenin. It is obtained by macerating for 24 hours the lichen in 18 parts of water, to which a little pearl-ash has been added (1 part to 16 of the moss). The alkali dissolves out a bitter principle. The water is poured off and pure water re-applied, until all alkalinity is removed. One pound of the softened lichen is then boiled in 9 of water, till the whole is reduced to six pounds. The whole is thrown upon a cloth, and the lichen subjected to pressure. What passes through is evaporated and dried. When in thin plates, it is transparent and tough. In its composition, it is believed to be isomeric with amidin.

Inulin, first obtained from the roots of the *Inula helenium*, but now known to exist in those of many other plants, as in *Anthemis pyrethrum*, *Colchicum autumnale*, *Dahlia pinnata*, *Helianthus tuberosus*, *Menyanthes trifoliata*, *Leontodon taraxicum*, *Cichorium intybus*, &c. It is obtained by boiling the roots in water for some time: the liquid on cooling, deposits the inulin in the form of a white powder. It is odorless and tasteless. Sp. gr. = 1.35. 100 of cold water, take up but 2 of inulin. Insoluble in alcohol.

Lignin, the fibrous portion of wood, freed of associated principles by digestion in water, alcohol, ether, hydrochloric acid, solution of potassa and chlorine water. It consists of $C^{15}H^{10}O^{10}$.

Fungin, the fleshy part of mushrooms. It is insoluble in water, alcohol, ether and oils.

Diastase, a substance which is extracted from malted barley. The ground malt is macerated for some time in cold water, and the liquid pressed out and heated to 158° . The fluid coagulates: the liquid is filtered, and alcohol added, when the diastase is thrown down; the sugar, coloring matter and the residue of the azotized matter remaining in solution. It is a white, amorphous substance, insoluble in absolute alcohol, but soluble in water and proof spirits. When heated to 150° or 167° with flour or starch, it detaches the envelopes from the amidin, and enters into combination with it, causing it to form a solution in water.* It exists in the seeds of several grains, and in the tubers of the potatoe.

Olivilin (Lecca gum). From an exudation of the *Oliva europæa*, or common olive tree. The gum is digested in ether, to remove a resin: the undissolved portion is then treated with absolute alcohol, which, on evaporation, lets fall brilliant, white crystals of olivilin. Its taste is sweet, bitter and aromatic. It melts at 158° . It is scarcely soluble in cold water. It consists of $C^6H^{4\frac{1}{2}}O^2$.

Columbin, found in the columbo root (that from Africa is the root of the *Cocculus palmatus*). The root is digested in ether, and the solution left to evaporate. The columbin falls in crystals, which are destitute of smell, but possess a bitter taste. They are but slightly soluble in alcohol, ether, or water. They consist of $C^{12}H^7O^4$.

VI. *Gums*. These principles have been arranged under three different heads, arabin, bassorin and cerasin.

Arabin. Gum arabic, an exudation from several species of *Acacia* (which grow in the Levant), consists almost wholly of arabin; the constituents of gum arabic being arabin 79.4, water 17.6, and ashes 3. The ashes are composed of the carbonates of potassa and lime, with traces of phosphate of lime, chloride

* Its name from διασταναι to separate, was given in consequence of its property of separating amadin from amylin.

of potassium, oxide of iron, alumina, silica and magnesia. Arabin is possessed of the following properties: it is colorless, odorless, and tasteless. Brittle when dry, but very tough when allowed to imbibe moisture. Between 287° and 392° , it softens, and may be drawn out into threads. Insoluble in alcohol. At 68° , an aqueous solution of it, containing more than 17 p. c. of arabin, will not filter through paper; nor at 212° , if it contain above 23.5 p. c. Such a solution is called mucilage. Boiled with sulphuric acid, arabin is converted into a sugar resembling manna. 100 of arabin heated with 400 of nitric acid (sp. gr. = 1.33), form 16.88 of mucic acid, together with a little oxalic acid. Arabin consists of $C^{12}H^{11}O^{11}$. Gum senegal is the produce of the *Acacia verek*, and comes from the west coast of Africa. It contains 80 p. c. of arabin.

Bassorin was first observed in a gum from Bassora; but was afterwards found to constitute a portion of gum-tragacanth, and of cherry-tree gum. To obtain bassorin, gum bassora is washed with cold water, till every thing soluble is taken up: the residue is dried upon a cloth and finally in a silver dish over a water bath. It is solid, colorless, tasteless and inodorous. It is insoluble in water; but only swells up and becomes gelatinous. It is insoluble in alcohol. 100 parts of it when heated with 1000 of nitric acid, form 22.6 of mucic acid, and at the same time, a little oxalic acid. With sulphuric acid, it forms a crystallizable sugar. It consists of $C^{10}H^{11}O^{11}$. Gum bassora is composed of water 21.89, ashes 5.60, arabin 11.20, bassorin 61.31. Gum tragacanth (the produce of the *Astragalus tragacantha* of Candia), of water 11.1, ashes 2.5, arabin 53.3, and bassorin (with starch) 33.1.

Cerasin, the name of the substance which remains undissolved when the gum of the cherry-tree is treated with cold water. It is tasteless, semi-transparent, insipid and inodorous. It swells a little in cold water, and is insoluble in alcohol. When boiled in water, it is converted into arabin. It is isomeric with arabin. The gum given out from the cherry-tree, apricot, plum, peach, and almond, consists of a mixture of arabin and cerasin.

Calendulin, obtained from the flowers of the *Calendula officinalis* (marygold). Insoluble in water, whether hot or cold; is yellow-

ish, translucent and brittle. When moistened with water, it swells up and is converted into mucilage.

Saponin, obtained from the root of the *Saponaria officinalis*, or of the *Gypsophila struthium*, by reducing it to powder, and boiling for a few minutes in alcohol. The solution on cooling, deposits the saponin in a white powder. It is soluble in water and alcohol.

VII. *Glutinous substances.* When the starch has been washed away from flour by cold water, there remains a grey, tenacious, ductile and elastic mass, called gluten. It adheres very tenaciously to other bodies (and is often used to cement together broken porcelain). Its smell is peculiar, and it is almost without taste. When dry, it is hard and brittle, having much the appearance of glue. When kept moist, it very soon undergoes a species of fermentation, emitting hydrogen and carbonic acid gases, and an odor very similar to that of putrefying animal bodies. Finally it acquires the smell and taste of cheese, is filled with little holes, having the very same juices which distinguish some kinds of cheese, and like it contains vinegar and ammonia. Gluten has been resolved into four distinct principles: viz. albumen, emulsin, mucin and gluten.

Albumen is obtained when fresh gluten from wheat is digested in alcohol, till every thing soluble is taken up: what remains is the albumen. It is soluble in water; but when the solution is heated, the albumen coagulates and becomes insoluble. It is readily soluble in caustic alkalies. When dry, it is opaque.

Emulsin exists in almonds. The milk of sweet almonds is mixed with 4 volumes of ether, and after the mixture is agitated, it is left at rest for four days. A clear liquid gradually separates, upon which the ether and a quantity of insoluble matter float. The clear liquor is drawn off and mingled with alcohol; emulsin is precipitated in white flocks, which are completely soluble in water, even after they have been dried.

Mucin is obtained by boiling alcohol upon the gluten of wheat; as the filtered liquid cools, this principle is deposited. It dries into transparent grains. It burns like animal matter.

Gluten is obtained by evaporating the alcoholic solution, after the mucin has been precipitated by cooling. It has the following

properties: soluble in alcohol, dilute acids and alkaline leys, but almost insoluble in water. It consists of $C^{3\frac{1}{2}}H^7HO$.

Zein, the name of the gluten obtained from Indian corn (*Zea mais*), and which, according to Professor GORHAM, differs essentially from that of wheat, by containing no nitrogen.

Viscin, obtained from a spontaneous exudation from the epidermis of *Robinia viscosa*, and from the involucre of *Atractylis gummifera*. When fresh, it is soft and elastic, and has a greenish or brownish color. It is insoluble in water and fixed oils, but is slightly soluble in alcohol, and very freely taken up by ether, and oil of turpentine. It is believed to be identical with the artificial bird-lime, which is usually prepared from the middle bark of the holly.

Pollenin, a peculiar substance found in the pollen of several species of the pine and of the *Lycopodium clavatum*, and supposed to constitute the characteristic ingredient of every species of pollen. Insoluble in water, alcohol, ether, oils and naphtha. In a moist situation, it is prone to undergo decomposition, attended with the odor of putrid cheese.

Legumin, a principle extracted from the seeds of all papilionaceous plants. It is a fine white powder, soluble in water, but insoluble in alcohol. BRACONNOT believes it to be possessed of alkaline properties.

Amygdalin, a substance obtained from the fruit of the bitter almond. It is without odor; is at first sweet, then bitter. It cannot be sublimed. It is not altered by exposure to the air: is scarcely soluble in cold alcohol, and is insoluble in ether.

Glairin, a substance found in certain sulphureous mineral waters. It gelatinizes, when the water containing it is sufficiently concentrated. It is sometimes white, at others, red. When dry, it shrinks to $\frac{1}{6}$ its bulk. When moist, it is without taste or smell. It is capable of putrefaction, like animal bodies, and emits ammonia when distilled. It is supposed to be of vegetable origin.

VIII. *Caoutchouc* (*India-rubber*). This well known principle is afforded by the *Lobelia caoutchouc* and the *Siphonia elastica*, of South America, and by the *Ficus Indica*, the *Artocarpus integrifolia*, and *Urceola elastica*, of the East Indies. Besides, it is

afforded by most of those plants which, when wounded, emit a milky juice, as the *Asclepias*, the *Papaver*, the *Lactuca*, &c. When pure, it has a pale, yellow color, and is destitute of taste or smell.

At 32° it is hard ; but at 60° or 70° , it becomes soft and pliable like leather. It is exceedingly elastic and adhesive. It is not altered by exposure to the air, and is perfectly insoluble in water. By long boiling in water, it softens and swells up, and is in a favorable state to be acted upon by different solvents. It is soluble in naphtha, ether, and in oils, both volatile and fixed. Acids and alkalies act very feebly upon caoutchouc. When heated to 248° , it melts, and when heated still higher in the open air, it smokes, and finally catches fire, burning with a strong, yellow flame. When distilled in close vessels, it affords $83\frac{1}{2}$ p. c. of a volatile oil (C^5H^4), which, when rectified, has a sp. gr.=0.64. It boils at 95° . By distilling caoutchouc at low temperatures, and exposing the products to the action of a freezing mixture surrounding the receivers, four different liquids have been obtained, viz. eupion, carburet of hydrogen (of FARADAY), caoutchene and heveëne.

IX. *Extractive*. The term extract was anciently employed to denote that portion of any vegetable substance which had been taken up by any solvent, and which had subsequently been recovered by the evaporation of the solution. By FOURCROY and VAUQUELIN (1790), an extract was a substance first soluble in water, but which on exposure to the air, became insoluble. They supposed the insolubility to be occasioned by the absorption of oxygen ; but SAUSSURE showed that it is rather owing to the evolution of hydrogen, whereby water is formed with the atmospheric oxygen. BERZELIUS calls this deposit apotheme. It is insoluble in water, unless hot ; but it is readily taken up by the alkalies, from which the acids precipitate it.

X. *Bitter Principles*. A great number of bitter principles are known, differing from each other, according to the plants from whence they are obtained. It is found when their infusions are treated with animal charcoal at from 77° to 86° , that they are nearly deprived of their bitter taste.

Quassite, from the common quassia of the shops, which is the product of the *Quassia amara* and the *Q. excelsa*.

Gentianite, from the *Gentiana lutea*.

Cytisite, from the *Cytisus laburnum*.

Bryonite, from the *Bryonia alba*.

Centauryte, from the *Centaurea benedicta*.

Arthanitite, from the *Cyclamen europæum*.

Bitter principle of wormwood, from the leaves of the *Artemisia absinthium*.

Colocynthisite, from the fruit of the *Cucumis colocynthis*.

Bitter principle of aloes.

Xanthopicrite, from the bark of the *Xanthoxylon carybæum*.

Berberite, from the bark of the *Berberis vulgaris*.

Lupinitite, from the leaves of the *Lupinus albus*.

Phloridzite, from the bark of the trunk and root, of the apple, pear, cherry and plumb.

Picrolichenite, from the *Variolaria amara*.

Scillitite, from the bulb of the *Scilla maritima* (squill).

Bitter principle of *Chena nova*, from the bark of the *China nova* and *C. regia*.

XI. *Products of the destructive distillation of vegetable substances*.—Some of these bodies are obtained from the mineral kingdom; but they are found under such circumstances as to render it probable that they were originally of vegetable origin, and have acquired their present properties from having been acted upon by heat.

Naphtha. It exudes from the earth in various parts of Persia, India, and the continent of Europe; and collects upon springs and lakes in Virginia, Kentucky, and New York, particularly at the Seneca lake, and hence it is called in the United States, Genesee, or Seneca oil. Its color is reddish brown, sometimes nearly black, when it is called mineral-tar. It has a strong bituminous smell. Sp. gr. = 0.75. It begins to boil at 320°, and on being distilled is colorless and transparent. When thus rectified, it boils at 180°. It is very inflammable. It consists of an equal number of atoms of carbon and of hydrogen, probably 12 of each.

Coal naphtha and petroleum. These are obtained from the distillation of an inspissated petroleum, bitumen, or bituminous coal, and do not differ sensibly from the true naphtha. Asphaltene is a black, pitchy bitumen, which remains after treating the bitu-

men of Bechelbronn (depart. Bas Rhine) with alcohol, and subsequently heating the bitumen for 50 hours at 482° .

Paraffin. This principle, described by REICHENBACH, exists in the tar obtained by the distillation of various substances, animal as well as vegetable. But the tar from beech wood is the best source of paraffin. The product of the distillation is three liquids. The heaviest of these is distilled again. As soon as what comes over begins to get thick, the receiver is changed, and the heat is raised till what comes over becomes black and thick. The receiver will now contain an oil, mixed with scales of paraffin. By washing these repeatedly with alcohol (sp. gr.=0.837), and finally by dissolving them in heated absolute alcohol, the paraffin is obtained in small white scales and needles. It has nearly the feel of spermaceti. It is tasteless and odorless. It melts at 110° . Sp. gr.=0.870. It burns with a white flame and no smoke, and consumes without residue. It has very little affinity to combine with other bodies, hence its name from *parum affinis*. A substance has lately been found in Moldavia, called fossil-wax, which appears identical with paraffin. It is composed like naphtha, of an equal number of atoms of carbon and hydrogen.

Eupion is obtained by distilling in a retort, the tar which is procured by decomposing animal muscle, bone, leather or horn, by distillation in the dry way, and more lately by distilling rapeseed-oil. The first and last portions are rejected, and only the middle one is reserved. It is a colorless liquid like water. Sp. gr.=0.65. It boils at 116° . It burns with a lively flame, unattended by smoke. Insoluble in water, but soluble in alcohol.

Creosote. This principle exists in impure pyroligneous acid, and in the tar obtained by the distillation of wood. To obtain the creosote, this oil is distilled anew in a glass retort. At a certain period of the distillation, the oil which comes over begins to sink to the bottom of the mixed product. The oil which swims is rejected. The heavy oil is dissolved in a solution of potassa: a portion of eupion mixed with other oils, swims on the surface, whence it must be removed: the alkaline liquid is poured into an open evaporating basin, and raised to the boiling temperature. It absorbs oxygen from the air; an oxidable matter contained in the liquid is decomposed by this absorption. When the liquid cools, dilute sulphuric acid is added, till the oil separates from the alkali.

The oil is mixed with water, containing a little potassa, and distilled. The creosote passes over slowly: but to purify it farther, the above steps are repeated three times. It is a transparent fluid. Sp. gr. = 1.037. Its odor is hot and penetrating, and its taste exceedingly caustic. It boils at $397\frac{1}{2}^{\circ}$, and does not congeal when cooled down to $16\frac{1}{2}^{\circ}$. It burns with a flame, at the same time emitting much smoke. With water at 60° , it forms two solutions, one containing 1.25 p. c. of creosote, the other 90 p. c. It is dissolved by acetic acid in every proportion. It combines readily with the alkalis; and dissolves many salts. It may be mingled in all proportions with alcohol, ether, bisulphuret of carbon, eupion, naphtha and acetic ether. Creosote dissolves the resins and coloring matters. It coagulates albumen. Fresh meat or fish, on being immersed in creosote, becomes incorruptible; the former assuming the odor of smoked meat; and since pyroligneous acid and smoke produce the same effects, it is believed that creosote is the antiseptic principle in these agents. When a drop of creosote is applied to the tongue, it occasions violent pain. It destroys the epidermis of the skin. It has been employed as a topical remedy in toothache, and as a cure for hemorrhages, ulcers, and even cancers.

Ampelin, an oily looking liquid, prepared from the oil of bituminous slate.

Picamare, obtained from the tar of wood.* It is a limpid, thick oil, having a peculiar odor and an insupportably bitter taste. Sp. gr. = 1.10.

Pittacall, an ingredient in wood-tar, which imparts a golden lustre to bodies over which it is spread, and hence its name from *πιττα* *pitch*, and *καλλος* *beautiful*. It is without smell or taste.

Capnomore, so named from *καπνος* *smoke*, and *μοιρα* *a part*, because it exists in the smoke of organic bodies. It occurs along with creosote, picamare and pittacall, in the heavy oil of tar. When pure, it is a colorless fluid, having the odor of rum. Sp. gr. = 0.97. It boils at 365° . It may be distilled over, without leaving any residue.

Cedriret is derived from the rectified empyreumatic oil, obtained by distilling the tar of beech-wood. It crystallizes in fine, red needles, which take fire and burn without residue.

* Name derived from *in pice amurum*, or the bitter principle in pitch.

Naphthaline is obtained by subjecting coal-tar to distillation. The first half of the product is rejected: the last third portion of the remaining half is rich in naphthaline. The crystals are freed from oil by pressure in blotting paper, and subsequently by sublimation. The crystals are white and pearly. Smell, aromatic. Heavier than water. Melts at 174° and boils at 410° . Does not burn readily. Slightly soluble in hot water; and dissolves readily in alcohol and ether, as well as in the oils, both volatile and fixed. It consists of $C^{10}H^8$. It dissolves in sulphuric acid, forming a new acid, which has been called sulpho-naphthalic acid. When a current of chlorine is passed over naphthaline it melts: the liquid gradually thickens, until at last a solid oleaginous body is formed, called solid chloride of naphthaline. It consists of $C^{10}H^3Cl^2$. Another combination of chlorine is called the oily chloride of naphthaline. It consists of $C^{10}H^{3.2}Cl^{1.1}$. When nitric acid and naphthaline are heated together, a yellow oil is formed, which is composed of two bodies, very soluble in alcohol and ether, one of which is solid; it is nitronaphthalase. It crystallizes in long square prisms. It melts at $109\frac{1}{2}^{\circ}$; and may be sublimed without decomposition. It consists of $C^{20}H^7NO^4$. When nitronaphthaline is boiled for a long time in nitric acid, a new crystalline compound is obtained, called nitronaphthalese. It forms minute needles, is insoluble in water, but very soluble in alcohol. Melts at 365° ; consists of $C^{20}H^6N^2O^8$. When nitronaphthalase is mingled with 8 or 10 times its weight of lime and distilled, a new compound called naphthalase is formed. It is insoluble in alcohol and water. It does not melt at 482° , but at that point, begins to sublime.

Paranaphthaline. When coal-tar is distilled, the products may be divided into four sets, the first of these is an oily product, which furnishes a good deal of naphthaline, the 2d yields naphthaline along with paranaphthaline, the 3rd product is viscid, and is composed almost wholly of paranaphthaline. It is purified by dissolving in oil of turpentine, and cooling down to zero. The paranaphthaline crystallizes in hard grains. They are washed in alcohol, and purified by repeated distillations. It melts at 356° ; boils at 572° . Scarcely soluble in alcohol. It consists of $C^{15}H^4$. By treating it with nitric acid and subliming the product, another

compound is obtained, called paranaphthalese. It is white, insipid, and may be volatilized. It consists of $C^{15}H^6O^2$.

Idrialin is a volatile solid, obtained from the distillation of a bituminous shale found in the mercury mines of Idria. It is composed of C^3H .

Eblanin, a substance found in raw pyroxylic spirit. It is obtained by distilling the spirit from quick-lime. The dry residue is a mixture of lime, acetate of lime and eblanin. Hydrochloric acid dissolves the lime, and the remainder is heated with warm alcohol. From this solution the eblanin is deposited in long needles. It has no smell. It is soluble in alcohol, ether, and concentrated acetic acid. It sublimes at 273° . This principle was called by Dr. GREGORY, by the name of pyroxanthin.

Lamp-black. The substances employed in its formation consist chiefly of carbon and hydrogen. They are exposed to a heat sufficiently high to volatilize them, while the supply of air is not sufficient to burn them completely. The consequence is, that the hydrogen burns in preference, being converted into water, while the charcoal thus liberated, is deposited under the form of soot, or lamp-black. The soot which collects in chimneys where wood is burnt, differs essentially from lamp-black. It has a bitter taste. When boiled with water, the fluid assumes a dark brown color, and lets fall on cooling, a matter which has the appearance of pitch. After frequent washings, it presents the characters of ulmin. The alcoholic solution of soot, gives on evaporation a yellow, oily looking body, called asbolin (from $\alpha\sigma\beta\omega\lambda\eta$ soot). The analysis of wood-soot by BRACONNOT, gives the following constituents.

Ulmin,	30.20
Animalized matter,	20.
Asbolin,	50
Water,	12.50
Carbonate of lime with carbonate of magnesia,	14.66
Acetate of lime,	5.65
Sulphate of lime,	5.
Acetate of potassa,	4.10
Charcoal,	3.85
Ferrophosphate of lime,	1.50

Silica,	0.95
Acetate of magnesia,	.53
Chloride of potassium,	.36
Acetate of ammonia,	.20
Acetate of iron,	trace.

Animal charcoal, or ivory black, is prepared by heating the bones of horses, sheep, and oxen, in close vessels, so as to drive off the volatile matter. The earth of the bones remains mixed intimately with the charcoal. It owes its efficacy as a discoloring agent, to the minute state of division in which the charcoal exists.

XII. Mellon and analogous compounds.

Mellon. When sulphuret of cyanogen (formed by passing chlorine through a solution of sulphocyanide of potassium) is heated to decomposition, a lemon-yellow powder remains, which has been called mellon. It is insoluble in water and all neutral liquids, which do alter its nature. At the fusing point of green glass, it is converted into cyanogen and nitrogen gases. It consists of C^2N^4 . Mellon dissolves in nitric acid, and gives rise to a liquid which is very acid, and contains ammonia and cyanilic acid, in long needles. During the preparation of sulphocyanide of potassium, a small quantity of a peculiar salt is obtained, found to contain an acid, called the hydromelonic acid. It is a white earthy powder, destitute of taste and smell.

Melam. When a mixture of 2 of sal-ammoniac and 1 of sulphocyanodide of potassium is distilled, the first effect of the heat is to disengage ammonia; then follows bisulphuret of carbon, while crystals of sulphuret of ammonium (sulphocyanodide of ammonium) collect in the neck of the retort. On connecting the retort with a refrigerating apparatus, the sulphuret of ammonium is entirely decomposed into ammonia, bisulphuret of carbon, sulphuret of carbon, sulphuretted hydrogen, and a new substance, to which LIEBIG has given the name of melam. It is a heavy, white powder. If boiled with nitric acid, it is entirely dissolved, and when the fluid cools, there fall down transparent crystals of cyanuric acid. When melam is fused with potassa, cyanic acid is formed. The liquid which has thrown down the cyanic acid, when neutralized, either by acids or by an excess of sal-ammoniac, yields a thick, white gelatinous precipitate; a substance

identical with that found, when melam is treated with hydrochloric acid; the substance is called melamin. It may be obtained in brilliant crystals. When melam is dissolved in concentrated nitric acid, it is converted into ammeline and ammonia.*

Melamin. It is prepared by taking the well washed residue from the distillation of 2 lbs. of sal-ammoniac and 1 lb. of sulphocyanodide of potassium, 2 oz. fused potassa dissolved in 3 or 4 lbs. of water, and boiling the whole for three days, adding water from time to time. It is finally evaporated for crystallization, when brilliant plates appear. These are purified by repeated crystallizations. They are soluble in hot water, but insoluble in ether or alcohol. Melamin combines with all the acids, forming well characterized salts. It is composed of $C^6H^6N^6$.

Ammelin. When melam is dissolved in potassa, melamin precipitates in plates, and ammelin remains in solution: on adding acetic acid, this substance falls as a bulky, white precipitate. It is insoluble in water, alcohol and ether; but is soluble in the alkalies and acids. It consists of $C^6H^5N^5O^2$.

Ammelide. Obtained by adding alcohol to a sulphuric acid solution of melam. The precipitate, after washing with water, is ammeline. It is a white powder, which possesses no alkaline properties. It consists of $C^6H^4\frac{1}{2}N^4\frac{1}{2}O^3$.

Chloride of cyanogen. Formed by the decomposition of sulphocyanodide of potassium, by chlorine gas. It is in brilliant needles, and consists of C^2NCl .

Cyanamide. Obtained by passing ammonia through chloride of cyanogen, placed in a horizontal tube. It is a white powder. It is composed of $C^1H^4N^4$.

CHEMICAL PHENOMENA OF VEGETATION.

The growth of a plant requires the presence of substances affording carbon and nitrogen, of water and its elements, and of a soil to furnish the inorganic constituents which enter more subordinately, but no less essentially, into their constitution.

Carbon of plants derived exclusively from the carbonic acid of the atmosphere.—Plants possess the power of decomposing the carbonic acid; their component parts resulting from the union of

* Dilute nitric acid forms with melam, ammeline and melamin.

the carbon with water, or its elements; while the atmosphere receives a volume of oxygen for every volume of the acid decomposed. The elements of water assimilated at the same time.—Connexion of the life of plants, with that of animals. Plants inspire carbonic acid, and expire oxygen: animals, on the contrary, give out carbonic acid, and consume oxygen. The roots, the leaves, and other green parts of plants, during the growing months, constantly absorb water and carbonic acid. In cloudy weather and the night time, carbonic acid is accumulated in all parts of their structure; but when the sun shines, the assimilation of carbon, and the exhalation of oxygen ensue.

Influence of shade on plants. During the night, the oxygen of the air acts upon the organic substance of the leaves, blossoms, fruits, and even wood of plants, in a manner independent of the life of the vegetable organism: the leaves and green parts containing volatile oils, which change into resin by the access of oxygen, absorb more than other parts. The leaves of such as secrete acids, are more sour in the morning than at night; being deprived of their acid properties during the day, by the separation of a part of their oxygen, to form compounds containing oxygen and hydrogen, either in the same proportions as in water, or even with an excess of hydrogen, as in bitter and tasteless substances.

The extrication of carbonic acid from plants during the night, is not owing to its formation in the plant; but is a part of that which has been absorbed from the air, and which, ceasing to be decomposed in the absence of light, escapes through the leaves, in quantity, corresponding to that of the water with which it is mingled.

Humus. The decay of woody fibre (the chief constituent of plants), gives rise to humus. While the change (called *eremacausis* by LIEBIG, meaning thereby a slow combustion), is going on, its carbon is constantly combining with oxygen from the air, thereby converting the oxygen into an equal volume of carbonic acid. If water is present, the process is hastened: alkalies also promote it; but acids and oils suspend it altogether. The conversion of oxygen into carbonic acid, proceeds more and more slowly, until at length, a brown, coaly substance remains, called mould, in which this property is wholly wanting. Humus then, is a con-

stant source of carbonic acid, and the process is promoted by tilling and loosening the soil, thereby causing a free access of atmospheric oxygen. The carbonic acid, which protects the undecayed fibres of plants from further change, is removed by the fine fibres and roots of young plants ; and fresh air is admitted, to give rise to a further eremacausis of the humus.

When plants are matured, they obtain their food from the carbonic acid of the atmosphere, through those organs which are situated above the surface of the ground, such as the leaves and other green parts of plants. The new products to which they give rise, after their own perfect development, serve for the formation of woody fibre, for sugar, starch and acids, which were before formed by the roots, when they were necessary for the development of the stem, buds, leaves and branches of the plant. When these depositions have proceeded to a certain extent, the expenditure of the nutriment is directed to the formation of flowers and fruit ; after which, they yield to the chemical influence of the air, change their color, and fall to the ground. A peculiar transformation of the matters contained in plants, takes place in the period between the blossoming and the ripening of fruits ; in consequence of which, various excrements are formed, some of which have carbon in excess, others nitrogen, and others again, hydrogen and oxygen. Such as are gaseous, escape by the leaves and corollas ; those which are solid, are deposited in the bark ; while fluid substances (particularly those abounding in carbon) are eliminated by the roots : and thus the soil reacquires the greatest part of the carbon, which it had at first afforded to the young plant as food, in the form of carbonic acid. Add to this quantity, the leaves which have fallen, and the dead roots of grasses and other plants, and it is plain that a soil receives more carbon than its decaying humus had lost, as carbonic acid. Humus then, does not, as was formerly imagined, nourish plants, by being taken up and assimilated in its unaltered state ; but by affording a slow and lasting source of carbonic acid to the roots, at a time when plants being destitute of leaves, are unable to extract nutriment from the atmosphere.

The assimilation of hydrogen. The solid part of plants (the woody fibre) consists of carbon and the constituents of water ; or

to express it differently, of the elements of carbonic acid and a certain quantity of hydrogen. Ordinary wood contains more hydrogen, than corresponds to the proportion in which it exists in water. Caoutchouc, wax and volatile oils, contain hydrogen in large quantity, and little or no oxygen. It is certain therefore, that plants have the power of decomposing water, since there is no other source whence it could be derived. The process of assimilation then, must consist in the extraction of hydrogen from water, and carbon from carbonic acid; in consequence of which, either all the oxygen of the water and of the carbonic acid is separated (as in the formation of caoutchouc and the volatile oils, which contain no oxygen), or else only a part of it is exhaled (as in sugar and tannic acid). The formation of the acids permits the smallest escape of oxygen, while that of the volatile oils excludes the whole.

The assimilation of nitrogen. Plants cannot thrive without the supply to them of nitrogen, since this element is found to exist in every part of the vegetable structure. The nitrogen of the atmosphere does not furnish their supply; but it is conveyed to their roots in the condition of carbonate of ammonia, and is derived from the putrefaction of animal matters. Ammonia is the last product of the decay of animal bodies: this gas rises into the air, meets with carbonic acid, and is brought down by rain, dew and snow.* Animal manure promotes the vegetable growth, solely by affording nitrogen in the form of ammonia. Putrid urine is more efficacious than the solid excrements of animals as a manure, from the fact of its richness in nitrogen, which exists in it in the forms of carbonate, phosphate and lactate of ammonia. The use of gypsum in agriculture, depends upon its fixing in the soil the volatile ammonia, brought down from the atmosphere by dews and rains, and which would otherwise be volatilized again, along with the moisture. The carbonate of ammonia is decomposed by the sulphate of lime; soluble sulphate of am-

* LIEBIG has detected ammonia in rain and snow water. When this is evaporated, an offensive smell (that of perspiration and animal excrements) is emitted. The sensation of softness in rain water, so different from that produced in distilled water, arises from the presence of carbonate of ammonia in the former. Springs very often contain carbonate of ammonia.

monia and carbonate of lime are formed, and this salt of ammonia not being volatile (like the carbonate of ammonia), is retained in the soil. Chloride of calcium (muriate of lime) in the soil, acts in a similar manner. Soils containing oxides of iron and alumina, and even charcoal, also act favorably in promoting the growth of plants, by their power of detaining ammonia.

Inorganic constituents of plants. These vary in some measure, according to the soils in which they grow; but a certain number of them are indispensable to the growth of plants. These substances are absorbed in the sap, and retained or rejected, as they may suit the purposes of vegetation. It is not known in what form silica, oxide of manganese and oxide of iron, exist in plants; but potash, soda, magnesia and lime, can be extracted from different parts of their structure, in the form of salts of organic acids. Oxalate of lime performs the functions of woody fibre in the lichens. The perfect development of a plant is dependent on the presence of alkalies, or alkaline earths. Saline plants require common salt. The plants which thrive in barn-yards, need ammonia and nitrates; and the different kinds of grain cannot thrive without a large supply of phosphate of magnesia and ammonia, and hence the necessity of strong manures in their cultivation. Sea plants require metallic iodides for their growth: but the sea contains 100 times more of carbonic acid than the air, in addition to a considerable content of ammonia.*

Nutrition and growth of plants. A peculiar process of vegetation takes place in plants, on the maturity of their fruit. The stems of annuals become woody, and their leaves change color. The leaves of perennials (trees and shrubs) remain in activity till the commencement of winter; the formation of wood proceeds, until after August, when the carbonic acid they absorb is employed in the production of nutritive matter, in the form of starch, for the following year, which is diffused through every part of the plant, by the autumnal sap. It is deposited also, in the roots and tubers of perennial plants. From this starch, sugar

* The atmosphere contains $\frac{1}{10000}$ th its weight of carbonic acid; a quantity, according to LIEBIG, sufficient to supply the present generation of plants with carbon, for 1000 years.

and gum are produced in the succeeding spring. After potatoes have sprouted, the quantity of starch in them is found to be diminished: and the juice of the maple ceases to be sweet, from the loss of its sugar, when its buds, blossoms and leaves attain their maturity. Upon the blossoming of the sugar cane, a part of the sugar disappears. It is found that the produce of potatoes is greatly augmented by plucking off the blossoms. The annual plants collect their future nutriment in the form of albumen, starch and gum, which they store up in their seeds, for the formation of their young leaves and first radicles. But starch, gum and sugar cannot be supplied to plants from without, as food; since, if they are introduced by the roots, the vital functions of the leaves, whose office it is to secrete them, must cease. In addition to starch, sugar and gum, the presence of gluten is necessary as a constituent of that stock of nutriment which is destined to aid in the development of the germ, leaves and first radicles. The starch is converted into sugar, and the gluten assumes a new form; both becoming soluble in water. The conversion of starch into sugar, during germination, is ascribed to a vegetable principle called diastase, which is generated during the act of commencing germination; a mode of germination which can only be effected by means of gluten.

The products generated by a plant vary, according to the food with which it is supplied. An excess of carbon, introduced through the roots, without being attended by nitrogen, cannot be converted into gluten, albumen, wood, or any other component part of an organ; but it may give rise to sugar, oil, resin, or gum; but if the food consist of ammoniacal salts, gluten, albumen and mucilage will be produced.

Composition of soils:—their fertility.—Fallow.—Interchange of crops.—Manures.

FERMENTATION, DECAY AND PUTREFACTION.

Modes in which decomposition takes place in organic chemistry.—None of the elements of the body decomposed, are singly set at liberty.

The causes which effect fermentation, decay and putrefaction.

“By the terms fermentation, putrefaction and eremacausis, are meant those changes in form and properties, which compound

organic substances undergo when separated from the organism, and exposed to the influence of water and a certain temperature." The elements of the bodies capable of undergoing fermentation and putrefaction arrange themselves into new combinations, in which the constituents of water generally take a part. "Ere-macausis (or decay) differs from fermentation and putrefaction, inasmuch as it cannot take place without the access of air, the oxygen of which is absorbed by the decaying bodies. Hence it is a process of slow combustion, in which heat is uniformly evolved, and occasionally even light. In the processes of decomposition, termed fermentation and putrefaction, gaseous products are very frequently formed, which are either inodorous or possess a very offensive smell." In those transformations where gaseous matters are evolved without odor, the term fermentation is employed; while to spontaneous decomposition, in which disgusting odors are emitted, the term putrefaction is applied.

Bodies which contain nitrogen appear to enter spontaneously into the states of fermentation and putrefaction; and it is known that small quantities of these substances in a state of fermentation or putrefaction, possess the power of causing unlimited quantities of similar matters to pass into the same state. Thus a small quantity of the juice of grapes in the act of fermentation, added to a large quantity of the same fluid which does not ferment, induces a similar commotion in the whole mass. This is an evidence of chemical action excited by contact with bodies already in the same condition, a property not peculiar to organic compounds.

During the decomposition of substances containing nitrogen, the water which is present suffers decomposition, the nitrogen being invariably liberated in the form of ammonia: acids and heat produce the same effect; and it is only when there is a deficiency of water or its elements, that cyanogen or other nitrogen compounds are produced.

Fermentation of Sugar. When a known quantity of sugar is dissolved in water, to which a portion of yeast has been added, and the mixture is exposed for twenty four hours to a temperature of from 68° to 77° , it is observed to pass through a gradual effervescence, during which carbonic acid is evolved, while the

water becomes saturated with the same gas, and contains also a certain amount of alcohol. If the carbonic acid and the alcohol be carefully estimated, it will be found that the entire carbon in them is exactly equal to that contained in the sugar out of which they have been formed; but there will be an excess of oxygen and hydrogen in the carbonic acid and alcohol, over that originally in the sugar, which excess must be owing to the elements of water having taken part in the metamorphosis of the sugar. The analysis of sugar proves, that it contains the elements of carbonic acid and alcohol, minus 1 atom of water. In the fermentation of the sugar, the elements of the yeast take no appreciable part in the transposition of the elements of the sugar. The juices of many vegetables however, contain along with sugar, a certain portion of albumen and gluten which act as yeast, and such fluids (beet-juice, parsnip-juice, &c.) undergo spontaneous decomposition (putrefaction) at temperatures from 95° to 104° : offensive gases are emitted; the nitrogen compounds disappear, but no alcohol is produced. The sugar has also disappeared, and the fluid contains lactate of ammonia, a crystalline body which forms the principal constituent of manna, and a viscous mass resembling gum arabic, which taken together equal in weight the sugar, the albumen and the gluten. They must therefore have been formed by the interchange of the elements of the sugar with those of the foreign substances referred to. But if the same juice had been treated with yeast at temperatures from 68° to 77° , it would simply have suffered fermentation, as in the instance of pure sugar just described.

Yeast (ferment). This substance, which causes the fermentation of sugar, is a compound into which nitrogen enters, and which is in a state of putrefaction and eremacausis. It converts the oxygen of the air into carbonic acid: under water it emits carbonic acid, together with offensive gases, and is at last converted into a substance resembling old cheese. When its own putrefaction is completed, it has no longer the power of inducing fermentation. When dried, its fermenting properties cease: boiling water, as well as antiseptic substances, render it inert. It produces fermentation in consequence of the progressive decomposition it suffers from the action of air and water.

When yeast is made to act on sugar, after the transformation of the sugar into alcohol and carbonic acid, it is found that a part of the yeast itself has disappeared, having suffered decomposition at the same time with the sugar. When the quantity of ferment is too small in proportion to that of the sugar, the yeast will be dissipated before all the sugar is decomposed; but when the quantity of ferment predominates, a certain quantity of it remains after all the sugar has fermented, its decomposition proceeding very slowly on account of its insolubility in the water. Nitrogen compounds are the only causes of fermentation and putrefaction in vegetable substances.

During the putrefaction of gluten, carbonic acid and hydrogen gas are evolved; phosphate, acetate, caseate, and lactate of ammonia being at the same time produced in such quantity that the further decomposition of the gluten ceases, unless the supply of water is renewed; when the decomposition recommences, and in addition to the salts just mentioned, carbonate of ammonia, caseous oxide, lactic acid, hydrosulphate of ammonia and a mucilaginous substance are produced.

“Dry distillation would appear to be a process of combustion, or oxidation going on in the interior of a substance, in which a part of the carbon unites with all or part of the oxygen of the compound, while other new compounds, containing a large proportion of hydrogen, are necessarily produced. Fermentation may be considered as a process of combustion or oxidation of a similar kind, taking place in a liquid between the elements of the same matter, at a very slightly elevated temperature; and putrefaction, as a process of oxidation, in which the oxygen of all the substances present come into play.”

Eremacausis. The act of gradual combination of the combustible elements of a body with the oxygen of the air, a property which is most conspicuous in bodies containing nitrogen.—Some matters oxidize in the air when simply moistened with water; others not until they are subjected to the action of alkalies; but the most of them suffer this change, when brought into contact with other decaying matters. The process is suspended by all those substances which impede fermentation or putrefaction. The action of oxygen seldom affects the carbon of decaying

bodies, a fact which corresponds to what happens in combustion at high temperatures ; since it is well known that when no more oxygen is admitted to a compound of carbon and hydrogen, than is sufficient to combine with its hydrogen, the carbon is not burned, but is simply separated as lamp-black. It would appear that carbon never combines with oxygen at common temperatures.

Substances which undergo eremacausis, have been divided by LIEBIG, into two classes: the first, consisting of those substances which unite with the oxygen of the air, without evolving carbonic acid ; and the second, such as emit carbonic acid by absorbing oxygen. When the oil of bitter almonds is exposed to the air, it absorbs two equivalents of oxygen, and is converted into benzoic acid ; but half of the oxygen absorbed combines with the hydrogen of the oil and forms water, which remains in union with the benzoic acid : now it is possible that the other portion of oxygen may unite with carbon in consequence of having obtained from its contact with hydrogen in eremacausis, a property which it does not itself possess at common temperatures. But the formation of carbonic acid during the eremacausis of bodies which contain hydrogen, must in most cases, be differently explained. The absorption of oxygen by drying oils, at least, does not depend upon the direct oxidation of their carbon, for in raw nut-oil, which was not free from mucilage and other substances, only 21 volumes of carbonic acid were formed for 146 of oxygen absorbed. Moist woody fibre (which consists of carbon and the elements of water) evolves one volume of carbonic acid for each volume of oxygen absorbed ; but as the oxygen and hydrogen of the fibre are not united in the form of water, it is supposed that the oxygen unites directly with hydrogen, thus leaving the oxygen of the woody fibre to combine with the carbon, by a transposition of elements, similar to that which gives rise to the formation of carbonic acid in the processes of fermentation and putrefaction,—the eremacausis of such substances being a decomposition, analogous to the putrefaction of bodies containing nitrogen.

Eremacausis of bodies which do not contain nitrogen. The juice of grapes, expressed under a receiver, filled with mercury, in order to exclude air, does not ferment ; but as soon as air is

introduced, oxygen is absorbed (or eremacausis ensues), and fermentation immediately begins. Animal food of every kind, as well as the most delicate vegetables, may be preserved unchanged, if heated to 212° in vessels, from which the air is completely excluded. The action of oxygen in this process, is to excite a change in the composition of the nitrogen compounds dissolved in the juice; and to cause the state of rest, to give place to one of motion, which when once established, the presence of oxygen is no longer necessary. The smallest particle of an azotized body in this act of decomposition, exercises an influence upon the particles in contact with it; and the state of motion is thus propagated through the entire mass, and the fermentation or putrefaction proceeds to its completion. The most general condition for the induction of eremacausis in organic matter, is contact with a body already in the state of eremacausis or putrefaction; thus decaying wood causes fresh wood with which it is in contact, to assume the same condition. In the manufacture of vinegar, the alcohol is exposed to a broad contact with air, and mixed with a substance (beer, acescent wine, a decoction of malt or honey), which is easily changed by the oxygen of the air, and either enters into eremacausis by mere contact with oxygen, or by its fermentation or putrefaction yields products possessed of this property, which impress the same condition upon the atoms of alcohol in its vicinity (precisely as in the case of an alloy of platinum and silver dissolving in nitric acid, in which the platinum becomes oxidized, by virtue of an inductive action which the silver in the act of its oxidation, exercises upon it): the hydrogen of the alcohol is oxidized at the expense of the oxygen in contact with it, forming water; the residue is aldehyde, which combining directly with oxygen produces acetic acid.

Eremacausis of substances containing nitrogen. When these substances are destroyed at high temperatures, the nitrogen does not combine directly with oxygen; the carbon and hydrogen with which the nitrogen is associated, having a stronger affinity for oxygen than the nitrogen. The nitrogen is given out in its gaseous form. "When a moist, azotized organic matter is exposed to the air, ammonia is always liberated, and nitric acid is never formed. But when alkalies or alkaline bases are present, a

union of oxygen with the nitrogen takes place under the same circumstances, and nitrates are formed, together with the other products of oxidation." Ammonia cannot be exposed to the action of oxygen, without the formation of an oxide of nitrogen, and in consequence, of nitric acid: and when enough air is admitted during the combustion of ammonia, water as well as nitric acid is formed, and the two new compounds unite. Indeed, the presence of water may be regarded as one of the conditions of nitrification, since nitric acid cannot exist without it. Ammonia may therefore be regarded as the general cause of nitrification on the surface of the earth,—azotized matter contributing to the production of nitric acid only, so far as it is a slow and continued source of ammonia.

Appendix to Vegetable Chemistry.

Komenic acid, derived from meconic acid by heat, or the reaction of a strong acid; also formed by boiling meconic acid in water, or in strong hydrochloric acid. It forms hard, crystalline grains or crusts. It produces a blood-red color with the per-salts of iron. When heated to 570° , it is resolved into pyromeconic acid, carbonic acid and water.

Tannic and gallic acids. These acids, though of very different composition, yield the same products (but in different proportions), by the action of heat; viz. metagallic, pyrogallic and carbonic acids, and water. Tannic acid may be viewed as a compound of gallic and pyrogallic acids.

Ellagic acid. When the infusion of nut-galls is exposed to the atmosphere, the tannic acid gradually disappears, and is replaced by gallic acid and ellagic acid, which last assumes the form of an insoluble, grey powder. When heated, it assumes a greenish yellow vapor, which condenses in greenish yellow crystals. It has been found in the root of the *Tormentilla officinalis*.

Catechu. The dried, watery extract of *Mimosa catechu*. It contains a large quantity of tannic acid. Soluble in cold water.

Catechine. The portion of catechu insoluble in cold water, contains catechine (tannigenic acid). It is soluble in hot water and in alcohol. It is a white powder, composed of silky needles. Exposed to the air in contact with caustic alkalis, it forms japonic acid ($C_2H_4O_4 + HIO$); and when treated with carbonated alkalis, it forms rubinic acid ($C_{18}H_6O_9$).

Cymen, cumin oil and cuminic acid. The Roman caraway oil (*Cuminum cyminum*) is a mixture of two substances, a hydrocarbon and a peculiar oil containing oxygen: the former may be driven off by distillation. When purified by potassa, the oil which was with it, is converted into an acid. The hydrocarbon is called cymen, the body changed into an acid, cuminol, and the acid itself, is called cuminic acid. Cumen consists of $C_{18}H_{24}$, cuminol of $C_{20}H_{24}O_2$, and cuminic acid of $C_{20}H_{24}O_4$.

Chelidonina and pirropina, two alkalis discovered by POTEX in the root of the *Chelidonium majus*: the former is composed of $C_{40}H_{40}N_6O_6$.

Jervin. A vegetable base, obtained along with veratrina and sabadillina, from the root of the *Veratrum album*. Its formula is $C^{60}H^{90}N^4O^5$.

Animal Chemistry.

Essential constituents of animal compounds, carbon, hydrogen, oxygen, and nitrogen. In addition to which there is often present, though in smaller quantity, phosphorus, sulphur, iron, and various saline and earthy matters. These compounds are distinguished from those of the vegetable kingdom, by the preponderance of nitrogen in the former, and the strong tendency to putrefaction, which it imparts to the compounds it aids in forming.

Proximate animal principles.

Fibrin. It constitutes that part of muscular fibre which is insoluble in water, as well as the coagulum of blood, after its coloring matter is removed. It is white, solid, tasteless, and without odor. While moist, it is somewhat elastic; and if left in a warm situation, it soon putrefies. Insoluble in water, at common temperatures. Alcohol (sp. gr. = 0.81) converts it into a fatty adipocircous matter, which is soluble in alcohol and ether, but is precipitated by water. All the acids except the nitric, render fibrin transparent and gelatinous: the diluted acids cause it to shrink up. By the action of nitric acid (sp. gr. = 1.25) aided by heat, a yellow solution is formed, with the extrication of a large quantity of pure nitrogen, which appears to be derived almost wholly from the fibrin. It is dissolved and partially changed by a solution of pure potassa: it is also soluble in ammonia. According to GAY LUSSAC and THENARD, its ultimate composition is as follows:

Nitrogen,	.	19.931 = 14 equivalents.
Carbon,	.	53.360 = 36 "
Hydrogen,	.	7.021 = 5 "
Oxygen,	.	19.685 = 16 "
		<hr/>
		100. 71

Albumen. This principle is the leading ingredient of the blood, and exists in many of the secretions; in a solid state, it abounds in the cellular membrane, the skin, cartilages and glands. It is obtained for experiment, from the white of an egg, and the serum of blood. A thick fluid, insipid, inodorous, and

easily miscible with water at common temperatures, in which it may be wholly dissolved. Moist albumen putrifies very rapidly; but when dried, it may be kept for any length of time. Albuminous liquids exert an alkaline reaction, from the presence of free soda. They are coagulated by heat, alcohol, and the stronger acids. Albumen is precipitated by several reagents. Corrosive sublimate causes a milkiness, when the albumen is diluted with 2000 parts of water. According to Rose, the precipitate is a compound of oxide of mercury and albumen. When an albuminous liquid is exposed to the agency of galvanism, pure soda makes its appearance at the negative wire, and the albumen coagulates around the positive wire. Albumen is composed of

Carbon,	.	50	=48 equivalents.
Hydrogen,	.	7.78	= 7 “
Nitrogen,	.	15.55	=14 “
Oxygen,	.	26.67	=24 “

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Gelatin. Obtained by boiling certain animal substances in water. The solution when concentrated, gelatinizes or concretes on cooling, which may be again liquefied and gelatinized by heat and cold. It exists most abundantly in the skin, cartilages, tendons, membranes and bones. Gelatin is remarkable for its easy solubility in water, and for the tendency which the solution has to gelatinize on cooling: 1 part of gelatin to 100 of water, becomes solid when the fluid is cold. It is insoluble in alcohol, ether, and in the fixed and volatile oils. It is soluble in strong solution of potassa, with the exception of a residue of phosphate of lime. The diluted acids also, form a good solvent for this principle. It manifests only a slight tendency to combine with metallic oxides. Sulphate of platinum throws it down in brown flocculi; and corrosive sublimate renders it turbid at first, and finally throws down a white, adhesive compound. Its most important property consists in its combining with tannic acid, in the formation of tanno-gelatin. This precipitated compound, when solutions of the two substances are mingled, is insoluble in water, dilute acids and alcohol, and when dried, becomes hard and brittle; but it softens again when soaked in water. On this property

is founded the art of tanning, or the conversion of skin into leather. The true skin of animals consists of organized gelatin, and when properly prepared and immersed in a solution of vegetable astringent matter (tannic acid), it becomes imbued with it, and combines with the tannic acid, thereby being converted into leather. Pure gelatin consists of

Nitrogen,	.	16.998=14	equivalents.
Carbon,	.	47.881=42	"
Hydrogen,	.	7.914=7	"
Oxygen,	.	27.207=24	"
		—	
		87	

Urea. Obtained by precipitating it from urine (which contains 30 parts of it to 1000), but still better artificially made, by heating a mixture of 28 dry ferrocyanide of potassium with 14 of black oxide of manganese.* The crystals are transparent and colorless, of a pearly lustre, and have the figure of four sided prisms. Taste resembles nitre. Sp. gr.=1.35. Fuses at 248° , and at a higher temperature is converted into carbonate of ammonia and cyanuric acid. Water at 60° , dissolves more than its weight of urea, and boiling water takes up an unlimited quantity. The aqueous solution of pure urea does not suffer decomposition on being boiled, or from exposure to the air; but as it exists in urine, it is almost wholly resolved into carbonate of ammonia, under both of these conditions. Urea is decomposed by the alkalies and alkaline earths, carbonate of ammonia being the principal product. Urea unites with the nitric and oxalic acids, forming slightly soluble compounds, which crystallize in pearly scales. The nitrate of urea consists of nitric acid 54.15 (1 eq.) + 60.54 urea (1 eq.). Urea contains the elements of cyanate of ammonia ($\text{NH}^4\text{O} + \text{C}^2\text{NO}$); it may also be considered, according to DUMAS, as a second compound of carbonic oxide and amide, in which the quantity of the latter is double that in oxamide $\text{C}^2\text{O}^2 + 2\text{NH}^2$.

* Ann. de Chem. und Pharm. vol. 38, part 1. Other processes are the following: concentrated urine may be mixed with a boiling saturated solution of oxalic acid: the oxalate of urea is digested with pounded chalk, when the urea separates. It can be prepared by the decomposition of cyanate of silver by sal-ammoniac, or the cyanide of lead by pure carbonate of ammonia.

Sugar of milk. Obtained by evaporating milk to the consistence of syrup, and allowing it to cool. Taste, sweet; requires 7 of cold and 4 of boiling water, for solution. Does not suffer the vinous fermentation, and when digested with nitric acid, yields saccholactic acid. It is analogous to common sugar in composition.

Sugar of Diabetes. Obtained in an irregularly crystalline mass by evaporating diabetic urine to a syrup, and keeping it in a warm place for several days.

Caseum. The curd separated by rennet from skim-milk, is a white insipid, inodorous substance, insoluble in water, but readily taken up by the alkalis. Its insolubility depends upon the presence of an earthy salt or acid, from which it may be freed, by allowing curd to separate spontaneously from milk, and digesting it with a solution of carbonate of potassa. When thus prepared, it is soluble in water; and on account of its great adhesiveness, is useful as a cement for glass, porcelain, wood, and paper. It may be dried, and in this state preserved for a long time; and when prepared with water, butter, and sugar, is said to be a good substitute for milk.

Mucus is a peculiar animal fluid, very abundant throughout the animal structure, characterized by being soluble both in hot and cold water. It is not precipitated by corrosive sublimate or tannic acid; neither does it form a jelly with water.

Hemosine (coloring matter of the blood). When dry, it is black, with a shining lustre. It is tasteless and odorless. It dissolves readily in cold water, forming a red liquid, which may be preserved for months without change. It is precipitated by alcohol and acids. The alkalis do not throw it down from its aqueous solution. With some of the metallic oxides, it forms insoluble compounds: the salts of tin and mercury, in particular, precipitate hemosine. Hemosine resembles albumen, excepting when derived from the human subject. It consists of carbon, hydrogen, nitrogen and oxygen, very nearly in the same ratio as in fibrin and albumen; but differs from them both in containing a little iron. The question as to whether or not, iron be really necessary to the existence of the red color of blood, cannot be considered as yet determined.

Animal oils. These contain oleine (which is liquid), stearine and margarine (both solid), united together in various proportions.

Tallow, the name given to the fat of oxen, sheep, deer and goats. It consists chiefly of stearine, with a little oleine. It forms with soda, firm hard soaps. Tallow soon becomes rancid on exposure to the air.

Butter is derived from the milk of the cow, and is purified from buttermilk, cheese, and other impurities by melting it, when the water subsides and the pure oil rises to the surface. It consists of margarine, oleine, butyrine, caprone and caprine. The three latter are compounds of oxide of glycerine with the volatile butyric, caproic and capric acids. Their quantity is small, but to them are owing the peculiar smell and taste of fresh butter. Butter soon becomes rancid, unless preserved by salt. Rancid butter may be rectified by melting and shaking it repeatedly, with twice its weight of boiling water.

Hogs' lard contains more oleine than tallow.

Human fat appears to contain no stearine.

Spermaceti, found in certain cavernous receptacles in the head of several species of *Physeter* and *Delphinus*. During the life of the animal, it is dissolved in the spermaceti oil; but after death, it is deposited on cooling, in a solid state. It consists chiefly of cetine contaminated by an oil, which is separated by alcohol. Pure cetine is crystalline; melts at 120° , and sublimes, undecomposed, at 670° . At a higher temperature, it yields inflammable gas. When saponified by fusion with potassa, it yields oleate and margarate of potassa, with ether.

Fish oil (train oil) has some resemblance to the drying oils, but it is distinguished by containing one or more volatile, oily acids in small quantity. Phocenic acid is one of these. The fish oils are composed of oleine with a little phocerine. They are used for lamps, and to mix with drying oils for soft soap.

Cholesterine (fat of bile), found in the blood, the brain, and the bile. It is the chief ingredient of biliary concretions: it is obtained by means of alcohol, which dissolves it out from associated principles. When the alcohol cools, the cholesterine is deposited in large, pearly scales. It fuses at 279° , and is volatilized in close vessels without change. Its formula is either

$C^{38}H^{76}O$ or $C^{36}H^{72}O$. When boiled with nitric acid, it gives rise to cholesteric acid, in pale yellow needles.

Ambreine, resembles cholesterine and occurs in ambergrise, a peculiar fat found floating on the sea in southern latitudes; and supposed to be a concretion from the stomach of the spermaceti whale. Ambreine is obtained by the action of alcohol on ambergrise. Nitric acid converts ambreine into ambreic acid.

Adipocire, obtained by exposing animal muscle for some time to the action of water, or of moist earth. It is supposed to consist of the fat associated with the fibrin in the muscle, the latter disappearing from decomposition. Adipocire is not pure fat, but a species of soap, consisting of margaric acid in combination with ammonia, generated during the decomposition of the fibrin.

Acids obtained from animal oils.

Three volatile acids of butter, the butyric, capric and caproic, obtained by decomposing a butter-soap with tartaric acid. When the butyrate of baryta is distilled, carbonate of baryta remains; and a volatile liquid (C^6H^6O), called butyrone, passes over. The caproate of oxide of glycerine exists in butter.

Hircic acid, from the soap formed by the fat of the goat.

Phocenic acid from the soap made with train oil (also from the leaves of the *Viburnum opulus*).

Margaric acid, the most important of the oily acids: it is found in combination with oxide of glycerine (sugar of oils, glycerule) in several species of animal and vegetable fats and oils, particularly in human fat,—goose fat being mixed with the oleate of glycerine. It is also produced by the action of heat on talow (stearate of glycerine). The alkaline margarates are soluble; those of baryta, lime and the metallic oxides, are insoluble. Margarate of glycerine (margarine), is the principal ingredient of human fat and of goose fat, combined however with the corresponding oleate. When distilled, with or without lime, margaric acid yields a white crystalline fat, called margarone.

Stearic acid is prepared by saponifying ox or mutton fat, by boiling it with potassa, precipitating by chloride of calcium, and decomposing the stearate of lime by hydrochloric acid. It is a firm, white solid; melts at 158° . Insoluble in water. Sp. gr.

=1.01. It burns like wax. When distilled, it is converted into margaric acid and margarone. Stearate of glycerine (stearine) is the chief ingredient of suet and tallow; and is the most important of the fatty bodies. Stearate of potassa forms an opaque viscid solution, with 10 of water. It is soluble in hot alcohol, and on cooling forms a jelly, known in medicine as opodeldoc. The stearates of earths and metallic oxides are insoluble. When stearic acid is distilled with lime, it yields a compound like margarone, but composed of $C^{46}H^{45}O$; while the analogous compound from margaric acid consists either of $C^{37}H^{33}O$ or $C^{34}H^{33}O$. Stearic acid on being digested with nitric acid, is converted into margaric acid; but if the action be continued, a deposit of suberic acid, containing succinic acid, is formed.

Oleic acid, may be obtained from mutton suet, ox fat, and from the oil of almonds. Combined with the oxide of glycerine, it is the principal ingredient of the fixed oils. It occurs in smaller quantity in animal fats, in large quantity in liquid animal oils, in bile along with stearic acid, and in the seeds of *Cocculus indicus*. To obtain it, oil of almonds is saponified, and the soap decomposed by an acid. It is an oily liquid; it has an acid reaction, and crystallizes in needles, when cooled below 32° . It is decomposed by heat into sebacic acid and other products. Nitric acid converts it into suberic acid, and nitrate of mercury into elaidic acid. The oleate of glycerine (oleine) is an ingredient in almost all oils and fats, in which it is mixed or combined with stearate or margarate of oxide of glycerine, or both. Its physical properties resemble those of almond oil. Sp. gr. = 0.9. The oleates of the alkalis are soluble, those of the earths and metallic oxides are insoluble.

Soaps and plasters. When fats and oils consisting of oleine, stearine, and margarine, each of which contain oxide of glycerine in combination with an oily acid, are acted on by alkalis, or by oxide of lead or zinc, these bases unite with the oily acids, forming in the first case soluble soaps, in the other, insoluble plasters. The oxide of glycerine at the moment of separation unites with water, forming hydrated oxide of glycerine. With ordinary fats, no other products are formed, but when the oil contains any of the volatile oily acids, such as butyric or pho-

cenic acid, the soap contains a salt of the volatile acid and acquires its smell. Soaps are divided into hard and soft. The former are obtained from fats or fat oils, the latter from drying oils. The soda-soaps are firmer than the potassa-soaps. Of the hard soaps, those made with vegetable oils are mixtures of oleate and margarate of potassa and soda; those made with animal fats are mixtures of stearate, margarate, and oleate of potassa or soda. When common salt is added to the solution of a soap of potassa, the latter is converted into soda-soap, entirely or partially, according to the quantity of salt, while chloride of potassium is formed. English soda-soap is made directly with caustic soda.

As the soaps of lime, baryta, earths and metallic oxides are insoluble, the use of hard water, which contains salts of lime, causes a precipitation of the insoluble soap. This may be corrected by adding previously to the water as much carbonate of soda, or potassa, as is sufficient to separate all the lime. The soap used in medicine is a hard soap made by boiling to dryness in a gentle heat, one part of soda ley (sp. gr. 1.33), and two of olive or almond oil. It is a mixture of margarate and oleate of soda, with free soda and glycerine. Antimoniated soap is made by dissolving one part of precipitated sulphuret of antimony in potassa, mixing the solution with six of medicinal soap, and evaporating to dryness. Litharge-plaster (diachylon plaster) is made by boiling five parts of levigated litharge (protoxide of lead) with nine of olive oil and some water, till the whole acquires a proper consistence. It consists chiefly of basic oleate and margarate of lead. White lead plaster (*Emplastrum cerussæ*) is made, by using 16 carbonate of lead to nine of olive oil. Iron-plaster and mercurial plaster are made by adding salts of mercury or iron to a solution of soap.

Uric acid and uric acid compounds. Uric acid exists in the excrements of serpents, of silkworms, is a product of secretion in all carnivorous animals and birds, and is deposited from human urine (as it cools, generally in combination with ammonia). The hard concretions found in the joints of persons laboring under gout, contain urate of soda or ammonia; while it is also the basis of the greatest number of urinary calculi. When pure, it presents itself under the form of fine, brilliant, white scales, which are tasteless,

inodorous, heavier than water; almost insoluble in cold, slightly soluble in boiling water, the solution feebly reddening the vegetable colors. It is taken up by concentrated sulphuric acid, from which it is precipitated by water. Exposed to destructive distillation, the products of the decomposition are the same as those of urea. All the urates are decomposed by other acids. Urate of ammonia (the excrement of serpents) is dissolved by boiling in a dilute solution of caustic potassa: on cooling (after filtration) the urate of potassa separates as a white crystalline mass. It is very sparingly soluble in water. Urate of soda is the principal constituent of gouty concretions.

Allantoin. When 1 of uric acid is boiled in 20 of water, and recently prepared and well washed peroxide of lead is added in successive portions, as long as its color changes, the hot liquid being filtered and evaporated, transparent crystals of a vitreous lustre are deposited. They were formerly called allantonic acid; but they are destitute of acid reaction. It occurs also readily formed, in the allantonic fluid of the cow. It is soluble in 160 of cold water. It consists of $C^4H^3N^2O^3$.

Alloxan, one of the products of the decomposition of uric acid by nitric acid. It was called erythric acid by BRUGNATELLI. It forms large, colorless crystals, which are very soluble in water, have a disagreeable odor, and a saline, astringent taste. It consists of $C^3N^2H^4O^{10}$. Treated with alkalies, alloxanic acid is formed; but on boiling, it is decomposed into urea and mesoxalic acid. When a solution of alloxan heated to 212° is treated with an excess of ammonia, and afterwards with sulphuric acid, on boiling a few minutes, a yellow gelatinous acid falls, called the mykomelinic. If equal parts of uric acid and alloxan be decomposed by nitric acid, colorless crystals of parabanic acid are formed. They are very soluble in water, and consist of $C^6N^2O^4 + 2(HO)$. The decomposition of this acid gives rise to oxaluric acid, which is a white crystalline powder. It consists of $C^6N^2H^3O^7 + HO$. By boiling in water, it is completely decomposed into free oxalic acid and oxalate of urea.

When alloxan is acted upon by sulphurous acid, thionuric acid is formed. It contains the elements of 1 eq. alloxan, 1 eq. ammonia, and 2 eq. sulphurous acid. Its formula is $C^3N^3H^7O^{14}S^2$.

Uramil is a product of the decomposition of thionuric acid. It may be considered as uric acid, in which the urea is replaced by 1 eq. ammonia and 2 of water. Its formula is $C^6N^3H^5O^6$. The uramilic acid, which is a product of the decomposition of uramil, is composed of $C^{16}N^5H^{10}O^{15}$.

Alloxantin, a product of the decomposition of uric acid by nitric acid. It is obtained from alloxan by hydrosulphuric acid. Its formula is $C^6N^2H^5O^{10}$.

Murexid (purpurate of ammonia of PROUT). A solution of uric acid in dilute nitric acid is evaporated until it acquires a flesh red color, when it is allowed to cool to 160° and treated to a solution of ammonia: the solution is then diluted with half its volume of boiling water, and allowed to cool. Murexid may be formed also, by bringing together many of the products of uric acid with ammonia. It crystallizes in short 4 sided prisms. Sparingly soluble in cold, but more readily, in hot water. Soluble in potassa, with a fine indigo-blue color. It is decomposed by hydrosulphuric acid into alloxantin, dialuric acid, murexan and sulphur. Its formula is $C^{12}N^5H^6O^8$.

Murexan is prepared by dissolving murexid in potassa by heat, which is applied till the blue color disappears, when dilute sulphuric acid is added in excess. It falls in crystalline scales of a silky lustre, but is taken up by ammonia and the fixed alkalies in the cold, without neutralizing them. If the ammoniacal solution of murexan be exposed to the air, it acquires a purple red color. Murexan is composed of $C^6N^2H^4O^5$.

Uric oxide (xanthic oxide), a rare constituent of urinary calculi. A pale yellow, hard mass, which acquires a waxy lustre by friction. It is dissolved by the pure and carbonated alkalies: and in small quantity by hot water, hydrochloric and oxalic acids. Soluble in concentrated sulphuric acid with a yellow color, no precipitation being occasioned by the addition of water: dissolves in nitric acid without effervescence. Exposed to the destructive distillation, it yields an odor of urine, hydrocyanic acid and carbonate of ammonia. Its formula is $C^5N^2H^2O^2$.

Cystic oxide, an organic base, which very rarely forms a constituent of urinary calculi. It exists in the calculus as a yellow-

ish white, crystalline mass of a brilliant lustre. It crystallizes from its solution in potassa, on the addition of acetic acid, in hexagonal plates; from ammonia, in white transparent scales. It is readily dissolved by the mineral acids, with which it forms crystalline compounds. It is soluble in pure and carbonated alkalies. It is decomposed by heat, with the evolution of sulphurous and ammoniacal products of an offensive odor. Its formula is $\text{C}^6\text{NH}^6\text{O}^4\text{S}^2$.

Composition of certain complex animal substances.

1. Bones. Bones of man and of the ox, when deprived of oil, blood and periosteum, have, according to BERZELIUS, the following composition :

	Bones of man.	Bones of oxen.
Cartilage completely soluble in water,	32·17	33·30
Vessels,	1·13	
Subphosphate of lime with a little fluuate of lime,	53·04	57·35
Carb. lime,	11·30	3·85
Phos. magnesia,	1·16	2·05
Soda with a little chloride of sodium,	1·20	3·45
	<hr/> 100·00	<hr/> 100·00

In birds there is more of the animal part which does not perfectly dissolve, than in mammalia. The earthy salts are not alike in different animals. BARRAS gives the following table :

	Phos. lime.	Carb. lime.
Lion,	95·0	2·5
Sheep,	83·0	19·3
Fowl,	88·9	10·4
Frog,	95·2	2·4
Fish,	91·9	5·3

Old bones contain more earth than young ones, and bones of the head have a greater proportion than those of the extremities. To the ingredients of human bones, modern research adds that of a small trace of arsenic.

2. Blood. The following table exhibits the results of two careful analyses of the blood by LECANU :

Water,	.	.	780·145	785·590
Fibrin,	.	.	2·100	3·565
Coloring matter,	.	.	133·000	119·626
Albumen,	.	.	65·090	69·415
Crystalline fatty matter,	.	.	2·430	4·300
Oily matter,	.	.	1·310	2·270
Extractive matter, soluble in water	}		1·790	1·920
and alcohol,				
Albumen combined with soda,			1·265	2·010
Chloride of sodium,	}		8·370	7·304
“ potassium,				
Carbonates,				
Phosphates,				
Sulphates,		of potassa and soda,		
Carbonates of lime and magnesia,	}		2·100	1·414
Phosphates of lime, magnesia and iron,				
Sesquioxide of iron,				
Loss,	.	.	2·400	2·586
			1000·000	1000·000

The relative proportion of the ingredients of the blood vary with the health, food, age and sex. LECANU analyzed blood drawn from ten men, and from ten women.

	Female.	Male.
Water,	804·37	789·32
Albumen,	69·72	67·50
Saline and extractive matter,	9·95	10·69
Red globules,	115·96	132·49
		1000·00 1000·00

Minute portions of alumina, silica and manganese, are also found in the blood. According to Dr. STEVENS, the saline matter of the blood gradually disappears in the progress of fever, and is almost entirely lost in its last stage: and the same is true, according to Dr. O'SHAUGHNESSY, in malignant cholera, sea-scurvy, and analogous diseases, produced by want and unwholesome nourishment. During inflammation, especially in acute rheumatism, the blood is unusually loaded with fibrin, and in jaundice, it is tinged with bile. The albumen is deficient in diseases of the kidney, which are characterized by anasarca, and

the passage of milky urine. Dr. BABINGTON mentions a case, in which nearly one eighth as much albumen was found in the urine, as in the blood. In chlorosis there is a deficiency of fibrin and hematosine, the water amounting to 871, instead of 780, the healthy standard.

3. Saliva. The solid contents of this fluid do not exceed seven parts in 1000, the rest being water. The principal saline ingredient is chloride of potassium; but sulphate, phosphate, acetate, and carbonate of potassa are likewise present. Concretions are sometimes found in the salivary glands and ducts, of which carbonate of lime is the chief constituent.

4. Pancreatic juice. It consists mostly of albumen, and a substance like caseum; but it also contains some salivary matter, and osmazome, as well as acetic acid.

5. Gastric juice. It is a transparent fluid, having a saline taste, but is destitute of an acid reaction, except during the process of digestion, when a secretion of the hydrochloric and acetic acids takes place, to which its solvent powers are ascribable.

6. Bile. A greenish yellow, viscid fluid, of a nauseous odor, and a taste at first sweet and then bitter. It contains a minute quantity of soda: but its chief ingredients are resin and a bitter principle, called picromel. According to TIEDEMANN and GMELIN, the bile of the ox has the following complex constitution:—water to the extent of 91·5 p. c.; a volatile odoriferous principle; cholesterine; resin; asparagin; picromel; yellow coloring matter; a peculiar azotized substance, soluble in water and alcohol; a substance which is soluble in hot alcohol, but insoluble in water, supposed to be gluten; osmazome; a principle which emits an urinous odor when heated; a substance analogous to albumen, or caseum; and mucus. The salts of the bile are the margarate, oleate, acetate, chlorate, bicarbonate, phosphate, sulphate, and hydrochlorate of soda, together with a little phosphate of lime.

Biliary concretions consist chiefly of a peculiar fatty matter, resembling spermaceti (adipocire): but CHEVREUL regards them as formed of the yellow coloring matter of the bile, and cholesterine. Gall-stones sometimes contain a portion of inspissated bile. A peculiar fluid was found by BIZIO, in the gall-bladder of

a person who died of jaundice. Its color was green, and it had the odor of putrid fish. He called it erythrogen. When digested in ammonia, or when volatilized in the open air, it yielded a purple colored vapor.

7. *Chyle and Lymph.* The fluids (analyzed by Dr. REES) were taken from the same animal, a young ass, which was killed by a blow on the head, seven hours after taking a full meal of oats and beans. The chyle was taken from the lacteal vessels, before entering the thoracic duct, and was therefore free from lymph: the latter fluid was taken from the lower extremity.

	Chyle.	Lymph.
Water,	90.237	96.536
Albuminous matter,	3.516	1.200
Fibrinous "	0.370	0.120
Alcoholic extractive,	0.332	0.240
Aqueous "	1.233	1.319
Fatty matter,	3.601	only a trace.
Salts, { alkaline (chloride, sulphate, and carbonate, traces of phos- phate), and oxide of iron, }	0.711	0.585
	<hr/> 100.000	<hr/> 100.000

The albuminous matter as obtained from the chyle, contained a substance in admixture, which gave it a dead, white color, resembling a substance existing in saliva.

8. *Urine.* An excretion for removing from the system, substances whose accumulation in the body would prove injurious to life: they consist of nitrogen compounds, and saline and earthy matters. The average sp. gr. of healthy urine is 1.02246. It reddens litmus from the presence of a free acid, or of a super-salt. On standing a short time, its transparency is affected by the deposition of a mixture of mucus and superurate of ammonia, which are more soluble in warm than in cold water. If kept for a day or two, it acquires a strong urinous odor; it becomes alkaline from the formation of carbonate of ammonia, in consequence of the decomposition of urea; and the earthy phosphates are deposited. According to BERZELIUS, 1000 parts of urine consist of

Water,	933.
Urea,	30.10
Uric acid (lithic acid),	1.00

Free lactic acid, lactate of ammonia, and animal matter, not separable from them,	} 17.14
Mucus of the bladder,	0.32
Sulphate of potassa,	3.71
Sulphate of soda,	3.16
Phosphate of soda,	2.94
Phosphate of ammonia,	1.65
Chloride of sodium,	4.45
Hydrochlorate of ammonia,	1.50
Earthy matters, with a trace of fluoride of calcium,	1.00
Silica,	0.03
Sulphur, phosphorus, yellow coloring matter, and albumen,	} traces.

Dr. PROUT believes the acidity of fresh urine to be occasioned by super-salts (superphosphate of lime, and superurate of ammonia), and not by uncombined acid.

Diabetic urine has a sweet taste, and yields a syrup by evaporation. The sp. gr. of such urine is as high as 1.03626: and has been found to contain in 1000 parts, 913 water, 60 of sugar, 65 urea, and 20 of salts.

An increased secretion of uric acid frequently takes place in urine: when the quantity amounts to more than can combine with the soda and ammonia, natural to this fluid, a deposition of free uric acid ensues; giving rise to gravel, when the crystals are detached from one another, and to stone when agglutinated together by animal matter, and mingled with the earthy constituents of urine. A deficiency of phosphoric acid in the urine leads to the deposition of the earthy phosphate, and to the formation of a different species of calculus.

In certain diseases of the kidneys, the quantity of albumen is greatly increased in urine; and the sp. gr. falls below the healthy standard from a deficiency of saline matter and urea.

9. *Urinary concretions.* The following varieties of calculi have been noticed: 1, the uric acid calculus; 2, the bone-earth calculus; 3, the ammoniaco-magnesian phosphate; 4, the fusible calculus; 5, the mulberry calculus; 6, the cystic oxide calculus.

1. The uric acid forms a hard, inodorous concretion, of a brownish, or fawn color, and smooth surface. It consists of concentri-

cally arranged layers, between which, there is sometimes interposed a thin portion of animal matter. It is very sparingly soluble in water and hydrochloric acid. It is quickly taken up by a solution of potassa; and the uric acid is thrown down on the addition of an acid. It is dissolved with effervescence by nitric acid; and the solution yields a purple color, when it is evaporated to dryness. When heated before the blowpipe, it becomes black, and emits a peculiar animal odor. After complete ignition, it leaves behind a white ash, which exerts an alkaline reaction. Under this head has been classed also, a very rare calculus, consisting of urate of ammonia, which is distinguished from that of uric acid by its solubility in boiling water when reduced to powder, and by its solution in potassa being attended with the extrication of ammonia.

2. The bone-earth calculus has a pale brown color, and presents an unusually smooth surface. When powdered, it dissolves with facility in dilute nitric or hydrochloric acid, but is insoluble in potassa. Before the blowpipe it first turns black, then becomes white, and finally enters into fusion.

3. Phosphate of ammonia and magnesia calculus is more or less blended with the other species. It is generally white, less compact than the foregoing varieties, and often invested by minute, shining crystals, which consist of pure phosphate of ammonia and magnesia. When powdered, this kind of calculus is dissolved by cold acetic acid and the stronger acids, the salt being thrown down unchanged, by ammonia. Digested in solution of potassa, an odor of ammonia is given off, but the powder is not dissolved. Before the blowpipe a smell of ammonia is given out; and a white pearly globule, more fusible than phosphate of lime, is obtained.

4. The fusible calculus is a mixture of the two preceding species. Its color is white, and when broken, it presents a ragged and uneven surface. It separates easily into layers, and is characterized by the facility with which it melts into a pearly, transparent globule. When powdered, and treated with cold acetic acid, the phosphate of ammonia and magnesia is dissolved, and the phosphate of lime, almost the whole of which is left, dissolves readily in hydrochloric acid.

5. The mulberry calculus is so called from its resemblance to the fruit of the mulberry. It consists of oxalate of lime. It is very hard and compact, and is covered by dark colored tubercles or protuberances. When heated before the blowpipe, the oxalic acid is decomposed and pure lime remains, which may be recognized by its alkaline reaction. It is insoluble in alkalies; but by digestion in carbonate of potassa, it is decomposed, and the insoluble carbonate of lime is formed. When powdered and treated with hydrochloric or nitric acid, a perfect solution is obtained; but it is not dissolved by acetic acid, which distinguishes it from the third species; nor by phosphoric acid, by which it is known to differ from No. 2.

6. The cystic oxide calculus is so rare, that but seven have been met with, in Great Britain. It is never accompanied with the matter of any other species, and it is found that the urine, during its formation, is rather more abundant than usual; is possessed of a sp. gr. = 1.020 to 1.022; is faintly acid, of a yellowish green color, and emits a peculiar odor, being at the same time deficient in uric acid and urea. A greasy looking film of cystic oxide collects on the surface of the urine, and a copious precipitate is thrown down by bicarbonate of ammonia, consisting of cystic oxide and the ammoniaco-magnesian phosphate.

In addition to the foregoing, Dr. MARCET has described a calculus under the name of xanthic oxide. Its color is yellowish red; it is soluble in alkalies and acids; and its solution in nitric acid, when evaporated, assumes a bright lemon-yellow tint, a property by which it is characterized, and to which it owes its name (*ξανθος*, yellow). Dr. M. describes a second calculus, under the name of fibrinous, from its resemblance to fibrin. A carbonate of lime calculus has been found; and silicious gravel has been voided, in a few cases.

POISONS, CONTAGIONS AND MIASMS.

Certain compounds, some of which are organic and others inorganic, produce peculiar changes in, and sometimes destroy the vitality of, the living animal organism. In the case of inorganic compounds, their action is either to destroy the continuity of particular organs, or to enter into combination with their substance. The strong mineral acids and alkalies are not strictly speaking

poisons, their injurious action depending merely upon their condition ; but an inorganic poison operates through an union with the constituents of the organ on which it acts, whereby a chemical affinity is exerted more powerful than the vitality of the organ.

Action of inorganic substances (salts) which are not deleterious. When solutions of salts are presented to different parts of the body, they are taken into the circulation, and may be again detected in the blood, perspiration, chyle, gall, and splenic veins ; and are finally withdrawn from the system, through the urinary passages. Some salts in their passage through the body exercise a medicinal action upon it, without themselves suffering any decomposition : others, as the neutral citrates, acetates and tartrates of the alkalies, suffer changes in their course through the organism : their acids become replaced by carbonic acid, a change which can only take place through the absorption of a large quantity of oxygen during their passage through the body. A part of the oxygen inspired, which under other circumstances combines with the blood, must when they are present combine with their acids, and thus be prevented from performing its customary office ; hence less arterial blood will be formed, or in other words, the process of respiration will be retarded.

Free mineral acids, or non-volatile organic acids, as well as salts of mineral acids with alkaline bases, assist decay in organic matters, and produce in living bodies the same phenomena as the neutral organic salts, but their action arises from a different cause. The absorption by the blood of a quantity of an inorganic salt, sufficient to arrest the process of *eremacausis* in the lungs, is prevented by the incapacity of all animal membranes, skin, cellular tissue, muscular fibre, &c., of being permeated by concentrated saline solutions. Fresh beef, over which salt has been strewed, is found after twenty four hours, swimming in brine, although not a drop of water has been added. The water is yielded by the muscular fibre, and having dissolved the salt in immediate contact with it, and thereby lost the power of penetrating animal substances, it has on this account separated from the flesh. The water still retained by the muscle, contains a small quantity of salt, having that degree of dilution, at which a saline fluid can penetrate animal matter. "When a solution of

a salt, in a certain degree of dilution, is introduced into the stomach, it is absorbed; but a concentrated saline solution, in place of being itself absorbed, extracts water from the organ, and a violent thirst ensues. Some interchange of water and salt takes place in the stomach; the coats of this viscus yield water to the solution, a part of which having previously become sufficiently diluted, is on the other hand absorbed. But the greater part of the concentrated solution of salt, remains unabsorbed, and is not removed by the urinary passages; it consequently enters the intestines and intestinal canal, where it causes a dilution of the solid substances deposited there, and thus acts as a purgative." The composition of the salts has nothing to do with their purgative action as a quality, but only in regard to intensity. It is immaterial whether the base be potassa, soda, or magnesia, and whether the acid be sulphuric, nitric or hydrochloric.

The action of the true inorganic poisons is very different; and depends upon their power of forming permanent compounds with the substance of the membranes and muscular fibre. "The salts of alkaline bases extract water from animal substances; whilst the salts of the heavy metallic oxides are, on the contrary, extracted from the water; for they enter into combination with the animal matters." Corrosive sublimate and arsenious acid possess in an eminent degree this property of entering into combination with all parts of animal and vegetable bodies, rendering them, at the same time, incapable of putrefaction; and if they are not prevented by the vital principle from entering into combination with the component parts of the body, they must deprive the organs of the principal property which belongs to their vital condition, viz. that of suffering and effecting transformations, or in other words, of organic life. "The compounds of arsenic which have not the property of entering into combination with the tissues of the organism, are without influence on life, even in large doses."

Antidotes to poisons are intended to act by preventing them from combining with animal matters. If the substance administered unite with the free poison, so as to produce an insoluble and undecomposable compound, the poison becomes inert; but so strong is the affinity of arsenious acid and of corrosive subli-

mate for animal matter, that when once compounds between them have been formed, no substance can be introduced into the stomach which is adequate to effect their disunion, without a still greater injury to the animal organization. Nitrate of silver would be attended with the same injurious effects as arsenious acid when taken internally, did it not meet with common salt and hydrochloric acid in the stomach, whereby it is instantly converted into chloride of silver, a compound which is insoluble in water, but very feebly soluble in common salt or muriatic acid; and it is this small portion, thus taken up, which exercises a medicinal effect, when nitrate of silver is given internally, the rest of the chloride of silver being withdrawn from the body in the usual way. The soluble salts of lead are equally deleterious with those of silver and mercury; but all compounds of lead with organic matters are capable of decomposition by dilute sulphuric acid: and hence the disease, called painters' colic, is removed in white lead manufactories, where sulphuric acid lemonade is used.

Salts of copper are reduced by many vegetable substances, such as sugar and honey, either into metallic copper or the red dinoxide, both of which are innocuous; hence sugar has long been employed as an antidote for poisoning by copper.

Organic poisons. These are generated during certain processes of decomposition. They act upon the animal economy as deadly poisons, not by entering into combination with it, but by a species of fermentation they impart to it, analogous to the commotion produced in a solution of sugar by yeast. And as yeast reproduces itself, provided its elements are contained in the saccharine fluid, so organic poisons, if added to fluids in which their constituents exist, may themselves be reproduced. This is the case with organic substances forming part of the animal organism. All the constituents of these substances are formed from the blood, which is so formed as to reproduce every part of the organism, its component parts being in a perpetual state of transformation, which is effected in the most various ways, through the influence of the different organs. The stomach for instance, causes all the organic substances conveyed to it to assume new forms, in order to the production of a compound, fitted for

the formation of blood. But the blood, on the contrary, possesses no power of causing transformations, its principal property being that of suffering transformations. Now if putrefying blood, cerebral matter, gall, pus, &c., be laid upon fresh wounds, vomiting, debility, and even death, may be the result. It frequently happens in the dissecting room, that very painful effects are experienced from cuts made by instruments, which have been used upon bodies in an advanced stage of decomposition. To the same class of effects, belongs the poisoning from eating the Würtemberg sausages. They are made from blood, liver, bacon, brains, milk, meal and bread; to which are added salt and spices. When there is a deficiency of seasoning, and particularly if they are smoked too late, or not enough, they undergo a kind of putrefaction, whereby they become paler, more soft and greasy; and are found to contain free lactic acid and lactate of ammonia. If eaten in this state, they occasion very lingering symptoms: there is a gradual wasting away of muscular fibre, and the patient finally dries to a complete mummy, and dies. The body becomes stiff as if frozen, and is not subject to putrefaction. Hundreds of cases are known of death thus occasioned, and which results from an action upon the organism, in consequence of the stomach and other parts with which the decomposed food comes in contact, not having the power to arrest their decomposition.

The *modus operandi* in these cases is found in this law, proposed by LA PLACE and BERTHOLLET, viz. a molecule set in motion by any power, can impart its own motion to another molecule with which it may be in contact—a law of dynamics, whose operation is manifest in all cases where the resistance of affinity or cohesion opposed to the motion, is not sufficient to repress it.

Poisons of the same sort are generated in the body in particular diseases, as small pox, plague, syphilis: substances of a peculiar nature are formed from the blood, which are capable of inducing in the blood of a healthy individual, a decomposition, similar to that of which they themselves are the subjects.

All those agents, such as a boiling temperature, contact with alcohol, acids, chlorine, and antiseptics generally, which retard fermentation, putrefaction and decay, completely arrest the action of the poisons just described.

"In order to explain the effects of contagious matters, a peculiar principle of life has been ascribed to them—a life similar to that possessed by the germ of a seed, which enables it under favorable conditions, to develop and multiply itself." But notwithstanding this representation is equally applicable to the fermentation of animal and vegetable substances, all the supposed proofs of vitality in the processes are to be regarded as merely figurative expressions, fitted to render our apprehensions of the phenomena more easy, without in the least degree explaining their true causes.

Contagion is the result of a peculiar influence, dependent on chemical forces. It is destroyed by chemical actions; and manifests itself, wherever it is not subdued by some antagonist power. "Its existence is recognized in a connected series of changes and transformations, in which it causes all substances, capable of undergoing similar changes to participate.

"Disease is excited by contagion. The transformations produced by the disease assume a series of forms." In order to form a correct idea of these transformations, we must observe the changes to which substances more simply composed than the living body are subject, under the influence of similar causes. "When blood or yeast in the act of transformation, is placed in contact with a solution of sugar, the elements of the latter substance are transposed, so as to form alcohol and carbonic acid. A piece of the rennet-stomach of a calf in a state of decomposition, occasions the elements of sugar to assume a different arrangement. The sugar is converted into lactic acid, without the addition or loss of any element. When the juice of onions, or of beet-root, is made to ferment at high temperatures, lactic acid, mannite, and gum are formed. Thus, according to the different states of the transposition of the elements of the exciting body, the elements of the sugar arrange themselves in different manners, i. e. different products are formed. The immediate contact of the decomposing substance with the sugar, is the cause by which its particles are made to assume new forms and natures. The removal of that substance occasions the cessation of the decomposition of the sugar, so that should its transformation be completed before the sugar, the latter can suffer no further

change. In none of these processes of decomposition is the exciting body reproduced; for the conditions necessary to its reproduction do not exist in the elements of sugar.

“Just as yeast, putrefying flesh, and the stomach of a calf, in a state of decomposition, when introduced into solutions of sugar, effect the transformation of this substance without being themselves regenerated, in the same manner, miasms and certain contagious matters produce diseases in the human organism, by communicating the state of decomposition, of which they themselves are the subject, to certain parts of the organism, without themselves being reproduced in their peculiar form and nature, during the progress of the decomposition. The disease in this case is not contagious.

“Now when yeast is introduced into a mixed liquid, containing both sugar and gluten, such as wort, the act of decomposition of the sugar affects a change in the form and nature of the gluten, which is in consequence also subjected to transformation. As long as some of the fermenting sugar remains, gluten continues to be separated as yeast, and this new matter in its turn, excites fermentation in a fresh solution of sugar and wort. If the sugar however should be first decomposed, the gluten which remains in solution is not converted into yeast. We see, therefore, that the reproduction of the exciting body here depends:—1, upon the presence of that substance from which it was originally formed; and 2, upon the presence of a compound which is capable of being decomposed by contact with the exciting body.

“If we express in the same terms, the reproduction of contagious matter in contagious diseases, since it is quite certain that they must have their origin in the blood, we must admit that the blood of a healthy individual contains substances, by the decomposition of which, the exciting body or contagion can be produced. It must further be admitted, that when contagion results, that the blood contains a second constituent capable of being decomposed by the exciting body. It is only in consequence of the conversion of the second constituent that the original exciting body can be reproduced. A susceptibility of contagion indicates the presence of a certain quantity of this second body in the blood of the healthy individual. The susceptibility

for the disease and its intensity must augment, according to the quantity of that body present in the blood; and in proportion to its diminution or disappearance, the course of the disease will change. When a quantity, however small, of contagious matter, that is, of the exciting body, is introduced into the blood of a healthy individual, it will be again generated in the blood, just as yeast is reproduced in wort. Its condition of transformation will be communicated to a constituent of the blood; and in consequence of the transformation suffered by this substance, a body identical with or similar to the exciting or contagious matter, will be produced from another constituent substance of the blood."

A number of peculiar principles exist in the blood of some men and animals, which are absent from the blood of others. Thus the blood of the same individual contains in childhood and youth, variable quantities of substances which are absent from it in other stages of growth; and the susceptibility of contagion by peculiar exciting bodies in childhood, indicates a propagation and regeneration of the exciting bodies, in consequence of the transformation of certain substances which are present in the blood, and in the absence of which no contagion could ensue. "When the organs of secretion are in proper action, these substances will be removed from the system; but when the functions of those organs are impeded, they will remain in the blood or become accumulated in particular parts of the body. The skin, lungs, and other organs, assume the functions of the diseased secreting organs, and the accumulated substances are eliminated by them. If when thus exhaled, they happen to be in the state of progressive transformation, these substances are contagious, i. e. they are able to produce the same state of disease in another healthy organism, provided the latter organism is susceptible of their action—or in other words, contains a matter capable of suffering the same process of decomposition." The production of matters of this kind, may be occasioned by the manner of living: an excess of strong food may produce them, as well as a deficiency of wholesome food, or even want of neatness. "The action, as well as the generation of the matter of contagion, is according to this view a chemical process, participated in

by all substances in the living body, and by all the constituents of those organs, in which the vital principle does not overcome the chemical action. The contagion, accordingly, either spreads itself over every part of the body, or is confined particularly to certain organs.

“In the abstract chemical sense, reproduction of a contagion depends upon the presence of two substances, one of which becomes completely decomposed, but communicates its own state of transformation to the second. The second substance thus thrown into a state of decomposition, is the newly formed contagion. The second substance must have been originally a constituent of the blood: the first may be a body accidentally present: but it may also be a matter necessary to life. If both be constituents indispensable for the support of the vital functions of certain principal organs, death is the consequence of their transformation.”

Chemical actions are most easily propagated in the lungs, and hence diseases of these organs are most frequent. The lungs are fitted by nature to favor chemical action. The contact of air with venous blood is limited to a very short period of time by the motion of the heart, and any change beyond a certain point is, to a degree, prevented by the removal of the blood which becomes arterialized. Any disturbance in the functions of the heart, and any chemical action from without, even though weak, occasions a change in the process of respiration. Solid substances, such as furze, from cotton or wool, flour and inorganic bodies, occasion a deposition of solid matters from the blood, by which the action of the air upon the latter is altered or prevented.

When sulphuretted hydrogen and carbonic acid gases enter the lungs, they meet with less resistance to chemical action, in this organ than in any other. Slow combustion is thus promoted by all substances in a state of decay, also by ammonia and the alkalis; but it is retarded by empyreumatic substances, volatile oils, and acids. “Sulphuretted hydrogen produces immediate decomposition of the blood; and the sulphurous acid combines with the substance of the tissues, the cells, and the membranes.”

“When the process of respiration is modified by contact with a matter in the progress of decay, and this matter communicates

the state of decomposition of which it is the subject to the blood, disease is produced. If the matter undergoing decomposition is the product of a disease, it is called contagion; but if it is the product of the decay or putrefaction of animal and vegetable substances, or if it acts by its chemical properties (not by the state in which it is), and, therefore, enters into combination with parts of the body, or causes their decomposition, it is termed miasm.

“Gaseous contagious matter is a miasm emitted from blood, and capable of generating itself again in the blood; but miasm properly so called, causes diseases without being itself reproduced.”

Gaseous contagious matter consists of substances in a state of decomposition.—

Ammonia is produced in cases of contagious disease, and may readily be detected in the air of chambers, occupied by the diseased patients. The power of contagion is destroyed in such an atmosphere, by the slow evaporation of hydrochloric, acetic and nitric acids; or by the introduction of chlorine; but this latter agent is apt to prove injurious to the lungs, and on this account cannot be so freely used as the acids. LIEBIG considers the carbonic acid and sulphuretted hydrogen, which are frequently evolved from the earth in cellars, mines, wells, sewers, and other places, to be amongst the most pernicious of miasms. The former are removed by alkalies; the latter by burning sulphur, or the evaporation of nitric acid.

GLOSSARY.

- ACICULAR**, from *acus*, a needle ; having sharp points like needles.
- AERATION**, from *ἀηρ*, the air ; the saturation of a liquid with air.
- AERIFORM**, from *aer*, the air, and *forma*, a form ; having the form of air.
- AEROSTATION**, from *ἀηρ*, the air, and *ἵσταναι*, to weigh ; primarily it denotes the science of weights suspended in the air, but in the modern application of the term, it signifies the art of navigating the air.
- AMORPHOUS**, from *ἀ*, not, and *μορφή*, a form ; not possessing regular form.
- ANALYSIS**, from *ἀνα*, thoroughly, and *λυω*, to loosen ; the separation of a whole into parts.
- ANHYDROUS**, from *ἀ* not, and *ὕδωρ*, water ; containing no water.
- ANION**, from *ἀνα*, up, and *εἶμι*, to go ; that which goes up ; a substance which in electrolysis, passes to the anode.
- ANODE**, from *ἀνα*, up, and *ὁδός*, a way ; the way which the sun rises ; the surface at which the electricity passes into a body, supposing the currents to move in the apparent direction of the sun.
- AQUA REGIA**, i. e. **REGAL WATER**, a mixture of nitric and muriatic acids ; so called from its property of dissolving gold, held by the alchemists to be *the king of the metals*.
- AQUEO**, from *aqua*, water ; when prefixed to a word, denotes that water enters into the composition of the substance which it signifies.
- ARMATURE**, from *armo*, to arm ; a piece of soft iron applied to a load-stone, or connecting the poles of a horse-shoe magnet.
- ATHERMANOUS**, from *ἀ*, not, and *θερμός*, heat ; that, through which heat will not pass, is said to be athermanous.
- AUSTRAL**, from *auster*, the south ; southern.
- BIBULOUS**, from *bibo*, to drink ; that which has the quality of drinking in moisture.
- BIFURCATION**, from *bis*, twice, and *furca*, a fork ; a forking or division into two branches.
- BINARY**, from *bis*, twice ; containing two units.
- BOREAL**, from *boreas*, the north ; northern.
- CALORIFIC** ; imparting the sensation and other effects of heat.
- CAPILLARY**, from *capillus*, a hair ; resembling or having the form of hairs.
- CATALYSIS**, from *κατα*, thoroughly, and *λύω*, to loosen ; an imaginary force which is supposed to assist the decomposition of some bodies, and the composition of others.
- CATHODE**, from *κατα*, downwards, and *ὁδός*, a way ; the way which the sun sets ; the surface at which electricity passes out of a body, supposing the current to move in the apparent direction of the sun.
- CATION**, from *κατα*, down, and *εἶμι*, to go ; that which goes down ; a substance which in electrolysis passes to the cathode.
- COMBUSTION**, from *comburo*, to burn ; the disengagement of light and heat which accompanies chemical combination.
- CONDUCTION**, from *con*, together, and *duco*, to lead. The power of transmitting caloric without change in the relative position of the particles of the conducting body.
- CONGELATION**, from *con*, together, and *gelo*, to freeze ; the process of freezing.
- CONGERIES**, from *congeries*, a heap ; a mass of bodies heaped up together.
- CONVECTION**, from *con*, together, and *veho*, to carry ; the power in fluids of transmitting heat or electricity by currents.
- CORPUSCULAR**, from *corpus*, a body ; composed of, or relating to atoms.
- CRYOPHORUS**, from *κρύος*, cold, and *φέρω*, to produce ; an instrument for showing the relation between evaporation at low temperatures and the production of cold.
- DECOMPOSITION** ; the resolution of a compound body into its component parts.
- DECREMENT**, from *decreresco*, to grow less ; the quantity by which any thing decreases or becomes less.
- DEFLAGRATION**, from *deflagro*, to burn ; burning.
- DELIQUESCENT**, from *deliqueo*, to melt ; a gradual melting, caused by the absorption of water from the atmosphere.
- DEPHLOGISTICATED** ; deprived of phlogiston, the supposed principle of inflammability.
- DIAPHANOUS**, from *δια*, through, and *φαίνω*, to shine ; that which allows a passage to the rays of light.
- DIATHERMANOUS**, from *δια*, through, and *θερμός*, heat ; that through which heat will pass is said to be diathermanous.
- DIELECTRIC**, from *δια*, through, and *ἤλεκτρον*, electricity ; a substance through which electricity may be transmitted.
- DIFFACTION**, from *dis*, signifying division, and *frango*, to break ; the deviation of rays of light from their straight course, when made to pass by the boundaries of an opaque body.
- DILATATION**, from *differo*, to bear apart ; the act of extending into a greater space.
- DIMORPHOUS**, from *dis*, twice, and *μορφή*, a form ; having two forms.

- DISC**, from *discus*, a quoit; the apparent surface of a heavenly body.
- DISINTEGRATION**, from *dis*, meaning separation, and *integer*, whole; an utter separation of particles.
- DISRUPTION**, from *dis*, in different directions, and *rumpo*, to break; the act of tearing asunder.
- DIVELLENT**, from *divello*, to tear asunder; that which causes separation.
- DYNAMICS**, -ICAL, from *δυναμις*, power; that branch of mechanical science, which treats of moving powers, and of the action of forces on solid bodies, when the result of that action is motion.
- EDUCT**, from *e*, out of, and *duco*, to draw; any thing separated from another with which it previously existed in combination.
- EFFLORESCENCE**, from *effloresco*, to blow as a flower; the formation of small crystals on the surface of bodies, in consequence of the abstraction of moisture from them by the atmosphere.
- ELECTRODE**, from *ἤλεκτρον*, electricity; and *ὁδός*, a way; the point at which an electric current enters or quits the body through which it passes.
- ELECTROLYSIS**, -LYTE, &c., from *ἤλεκτρον*, electricity, and *λύω*, to loosen; the act of decomposing bodies by electricity.
- EMPIRICAL**, from *ἐν*, in, and *πειράσθαι*, to make trial; that which is made, or is done, as an experiment, independently of hypothesis or theory.
- EMPYREUMATIC**, from *ἐν*, in, and *πῦρ*, fire; having the taste or smell of burnt animal or vegetable substances.
- ENDOSMOSE**, from *ἐνδόν*, within, and *ὥσμος*, the act of pushing; a flowing from the outside to the inside.
- EQUILIBRIUM**, from *æquus*, equal, and *libra*, a balance; the state of rest produced by forces equally balancing one another.
- EQUIVALENT**, from *æquus*, equal, and *valeo*, to be worth; equal in value.
- EREMACAUSIS**, from *ἥρμα*, slow, and *καυσίς*, combustion; the gradual combination of the combustible elements of a body with the oxygen of the air.
- ETIOLATION**; the blanching of vegetables by exclusion from light.
- EXOSMOSE**, from *ἐξω*, without, and *ὥσμος*, the act of pushing; a flowing from inside to the outside.
- FORMULA**, a general theorem; it is called algebraic, logarithmic, &c., according to the branch of mathematics to which it relates.
- HELIX**, from *ἑλίσσω*, to twist round; a screw, or spiral.
- HERMETIC SEAL**; when the neck of a glass vessel or tube is heated to the melting point, and then twisted with pincers until it be air-tight, the vessel, or tube, is said to be hermetically sealed, or to have received the seal of Hermes, the reputed inventor of chemistry.
- HYDRACID**, an acid formed from the union of a simple or compound body with hydrogen.
- HYDRATE**, from *ὕδωρ*, water; any uncrystallized substance which contains water in a fixed definite proportion.
- HYDRO**; when prefixed to the name of a chemical substance, denotes that hydrogen enters into the composition of the substance which it signifies.
- HYDROMETER**, from *ὕδωρ*, water, and *μετρον*, a measure; an instrument for comparing the density and gravity of liquids with water.
- HYDROSTATICS**, from *ὕδωρ*, water, and *στατός*, standing; that branch of natural philosophy, which treats of the pressure and equilibrium of non-elastic fluids, and also of the weight, pressure, &c., of solids immersed in them.
- HYGROMETER**, from *ὕγροις*, moist, and *μετρον*, a measure; an instrument for ascertaining accurately the quantity of moisture in the atmosphere.
- HYPO**, from *ὑπέρ*, under; when prefixed to a word, denotes an inferior quantity of some ingredient which enters into the composition of the substance which it signifies.
- HYPOTHESIS**, -TICAL, from *ὑπέρ*, under, and *τίθημι*, to place; a principle supposed or taken for granted in order to prove a point in question.
- INCANDESCENT**, from *incandesco*, to grow white; white or glowing with heat.
- INCREMENT**, from *increSCO*, to increase; the quantity by which any thing increases or becomes greater.
- INDUCTION, ELECTRICAL**; the effect produced by the tendency of an insulated electrified body to excite an opposite electric state in neighboring bodies.
- INERTIA**, from *inertia*, inactivity; the disposition of matter to remain in its state of rest or motion.
- INSULATION**, from *insula*, an island; when a body, containing a quantity of free heat, or of electricity, is surrounded by non-conductors, it is said to be insulated.
- ISOCHRONOUS**, from *ἴσος*, equal, and *χρόνος*, time; performed in equal times.
- ISOMERIC**, from *ἴσος*, equal, and *μερος*, a part; substances, which consist of the same ingredients, in the same proportion, and yet differ essentially in their properties, are called isomeric.
- LEVIGATION**, from *lævis*, smooth; the art of reducing to a light powder.
- LOADSTONE**, i. e. **LEADSTONE**; an ore of iron having magnetic properties.

- MAXIMUM**, from *maximus*, greatest; the greatest value of a variable quantity.
- METALLURGY**, from *μεταλλον*, a metal, and *εργον*, a work; the art of working metals and separating them from their ores.
- METHYLENE**, from *μεθυ*, wine; a compound resembling alcohol in its constitution.
- MINIMUM**, from *minimus*, least; the least value of a variable quantity.
- MOLECULES**, AR, a diminutive from *moles*, a mass; the infinitely small material particles of which bodies are conceived to be aggregations.
- MOMENTUM**, from *moveo*, to move; the product of the numbers which represent the quantity of matter and the velocity of a body, is called its momentum, or quantity of motion.
- MULTIPLE**, from *multiplico*, to render manifold; a quantity is said to be a multiple of another, when it contains that other quantity a certain number of times without a remainder.
- NASCENT**, from *nascor*, to be born; in the moment of formation.
- NORMAL**, from *norma*, a rule; according to rule.
- NUCLEUS**, from *nucleus*, a kernel; the central parts of a body which are supposed to be firmer, and separated from the other parts, as the kernel of a nut is from the shell; also, the point about which matter is collected.
- OSCILLATION**, from *oscillor*, to swing; the vibration, or reciprocal ascent and descent of a pendulum.
- OXIDIZABLE**; capable of being converted into an oxide.
- PELLICLE**, a diminutive from *pellis*, a skin, or crust; a thin crust formed on the surface of a solution by evaporation.
- PHLOGISTON**, from *φαιγε*, to burn; a name given by the older chemists to an imaginary substance, which was considered as the principle of inflammability.
- PHOSGENE**, from *φως*, light, and *γεννω*, to produce; produced by light.
- PHOTOMETER**, from *φως*, light, and *μετρον*, a measure; an instrument for measuring the different intensities of light.
- PNEUMATICS**, from *πνευμα*, air; that branch of natural philosophy, which treats of the weight, pressure, and elasticity of æriform fluids.
- POLARITY**; the opposition of two equal forces in bodies, similar to that which confers the tendency of magnetized bodies to point to the magnetic poles.
- POLARIZED LIGHT**; light, which, by reflection or refraction at a certain angle, or by refraction in certain crystals, has acquired the property of exhibiting opposite effects in planes at right angles to each other, is said to be polarized.
- POLES**; the extremities of the axis about which a body revolves.
- PRECIPITATION**, from *precipito*, to fall suddenly; the separation of a solid from a liquid.
- PYRO**; when prefixed to a word denotes that the substance which it signifies has been formed at a high temperature.
- QUALITATIVE**; regarding the properties of a body without reference to quantity.
- QUANTITATIVE**; regarding quantities.
- RADICAL**, from *radix*, a root; the original principle of a compound.
- REACTION**; the reciprocation of any impulse, or force impressed, made by the body on which such impression is made. Reaction is always equal to action.
- SALIFIABLE BASES**, from *sal*, salt, and *fiō*, to become; bodies capable of combining with acids to form salts.
- SAPONIFICATION**; the combination of an oil with an alkali to form a soap.
- SATURATION**, -ATED, from *satur*, full; the solution of one body in another, until the receiving body can contain no more.
- SOLVENT**; any substance which will dissolve another.
- SPECTRUM**; the colored image formed on a white surface by rays of light passing through a hole, and being refracted by a glass prism.
- SUBLIMATION**, from *sublimis*, high; the act of raising into vapor by means of heat and condensing in the upper part of a vessel.
- SULPHATIZATION**; the conversion of a metallic sulphuret into the sulphate of an oxide of the metal.
- SYNCHRONOUS**, from *συν*, together, and *χρονος*, time; performed in the same time.
- SYNTHESIS**, from *συν*, together, and *τιθημι*, to place; the composition of a whole from its parts; in mathematics, the process of reasoning out new principles from those already established.
- TENTATIVE**, from *tento*, to try; experimental.
- TERNARY**, from *ter*, thrice; containing three units.
- TRITURATED**, from *trituro*, to thrash; reduced to powder.
- TRUNCATION**, from *truncus*, cut short; the cutting off a portion of a solid, as of the solid angle of a crystal.
- VOLUME**, from *volumen*, a roll; the apparent space occupied by a body.
- ZERO**; the numeral 0, which fills the blank between the ascending and descending numbers in a series.